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Precambrian Geology of the Southern Black Sturgeon River and Seagull Lake Area, Nipigon Embayment, Northwestern Ontario

by

T.R. Hart

2005

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Miscellaneous Release—Data 147

Southern Black Sturgeon River–Seagull Lake Area, Nipigon Embayment, Northwestern Ontario: Lithogeochemical, Assay and Compilation Data

by T.R. Hart

This digital data release consists of chemical analyses and diamond drill hole information utilized in the geological interpretation presented on Preliminary Maps P.3562 and P.3563 as a result of mapping in the southern Black Sturgeon River to Seagull Lake area of the Nipigon Embayment, and is being released in conjunction with OFR 6165. Whole rock chemical data for representative samples consist of X-ray fluorescence (XRF), fused and pressed powder, major and trace elements, inductively coupled plasma mass spectrometry (ICP–MS) trace and rare earth elements and precious metals, inductively coupled plasma atomic emission spectroscopy (ICP–AES) metals and trace elements, and specific gravity measurements. Platinum group element analyses for a limited number of samples were completed using nickel fire assay–ICP–MS. Assay data for mineralized samples consist of metal and trace element analyses using ICP–AES. Both lithogeochemical and assay samples have associated rock descriptions and locations. Information from the Ontario Drill Hole Database (ODHD), supplemented with drilling information provided by companies currently exploring, or that have conducted past exploration, in this area, had drill hole positions verified and included as Universal Transverse Mercator (UTM) co-ordinates. Magnetic susceptibility measurements for most stations visited during the mapping project are annotated with the rock descriptions and locations. Also included are basic rock type information for the field mapping stations and photographic images labelled with locations. All positional data are provided in UTM projection and grid system, North American Datum 1983 (NAD83), Zone 16. The data are available as Microsoft® Excel 97 (*.xls*), Microsoft® Word 97 (*.doc*) or tab-delimited ASCII text (*.txt*) files, and image (*.jpg*) files on one CD-ROM.

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Precambrian Geology of the Southern Black Sturgeon River and Seagull Lake Area, Nipigon Embayment, Northwestern Ontario

T.R. Hart[1]

Ontario Geological Survey
Open File Report 6165
2005

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Ministry of Northern Development and Mines, Sudbury, Ontario P3E 6B5

Introduction

Bedrock mapping in the southern Black Sturgeon River and Seagull Lake area was completed to investigate the regional geological setting of the platinum group element (PGE) bearing mafic to ultramafic intrusion in the Seagull Lake area. The southern Black Sturgeon River and Seagull Lake map area is located approximately 85 km northeast of Thunder Bay and south of Lake Nipigon (Figure 1). The area mapped during the summer of 2004 extends from approximately latitude 48°48′N, longitude 88°20′N to latitude 49°14′N, longitude 89°03′W. Access is provided by the Black Sturgeon Road, which extends north from Highway 11/17 at Hurkett, the Dorion Cutoff Road, which extends west from Highway 11/17 at Dorion across to Highway 527, and the numerous logging roads branching off these 2 roads. The limits of the map area were governed by the interpreted position of the Black Sturgeon fault zone, the location of the ultramafic intrusions at Seagull Lake and Hele Township, and the extents of the Sibley Group (Figure 2).

This project was the second year of mapping completed by the Ontario Geological Survey as part of its commitment of in-kind support to the Lake Nipigon Region Geoscience Initiative (LNRGI). The LNRGI is a geoscience-based geological data acquisition and compilation program operated by the Ontario Prospectors Association (OPA) and funded through an agreement with the Northern Ontario Heritage Fund Corporation (NOHFC). The LNRGI also includes partnerships with the private sector, Lakehead University and communities in the Lake Nipigon area. The major aim of the initiative is to attract interest from international and domestic investors to encourage new mineral exploration

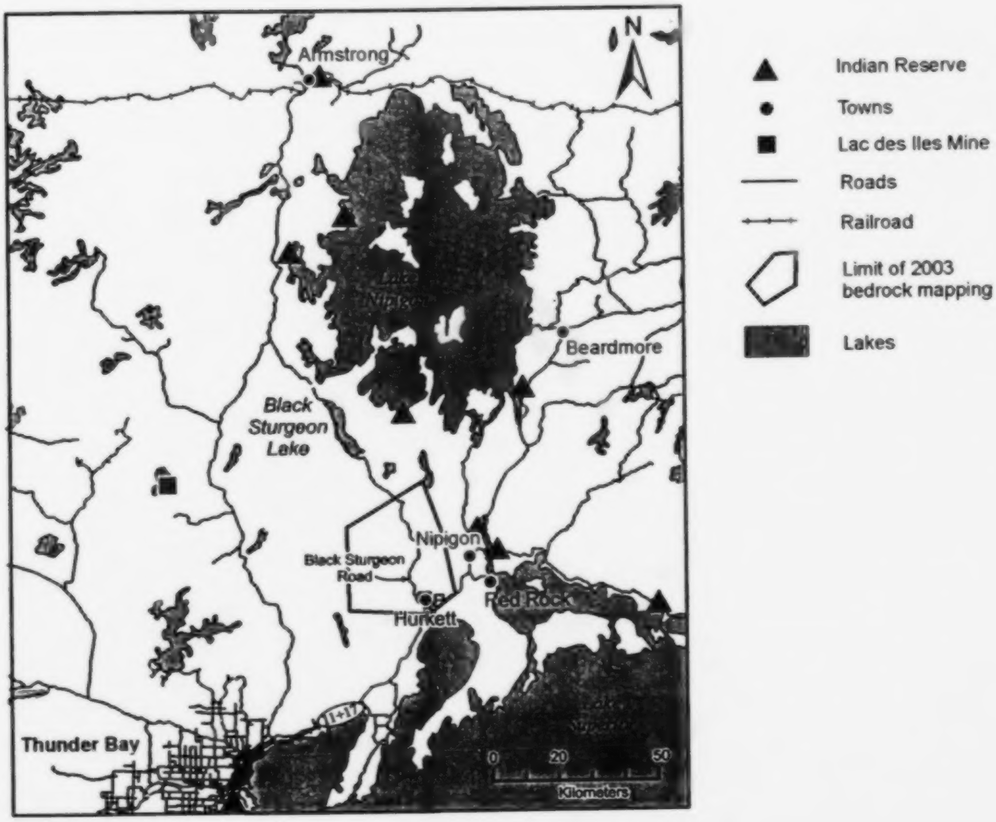
Armstrong
N
Lake Nipigon
Beardmore
Black Sturgeon Lake
Nipigon
Black Sturgeon Road
Hurkett
Red Rock
11+17
Thunder Bay
Lake Superior
0
20
50
Kilometers
Indian Reserve
Towns
Lac des Iles Mine
Roads
Railroad
Limit of 2003 bedrock mapping
Lakes

Figure 1. Map showing location of study area.

Introduction

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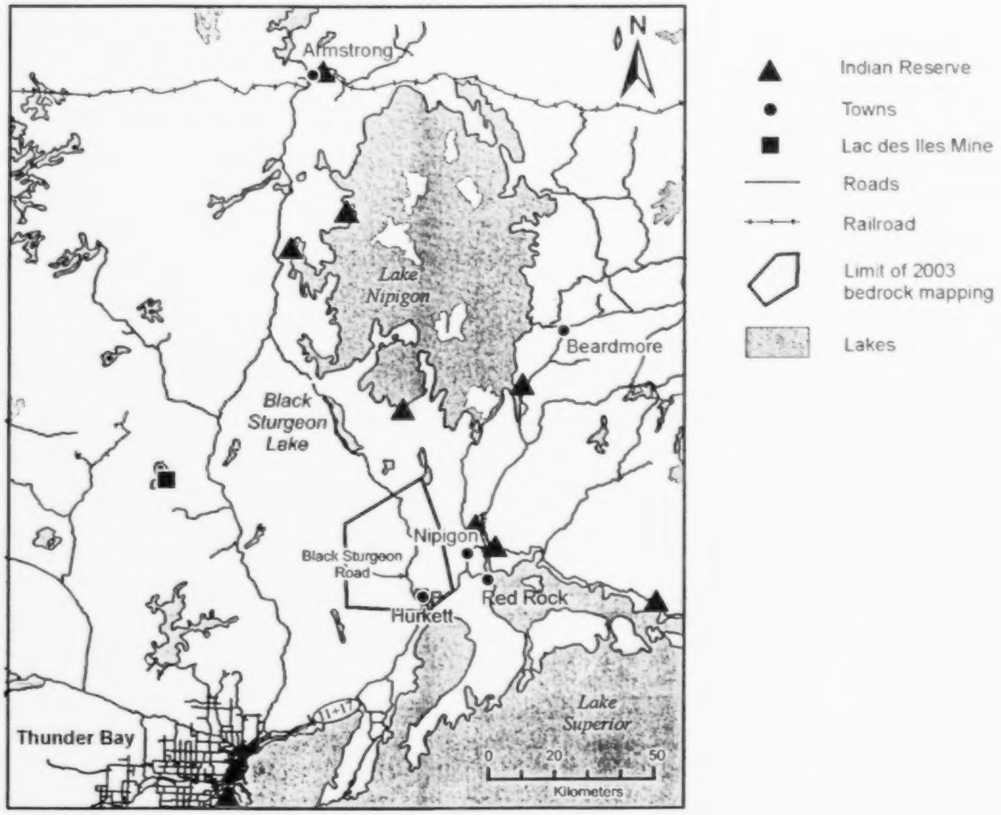
Armstrong
N
Lake Nipigon
Beardmore
Black Sturgeon Lake
Nipigon
Black Sturgeon Road
Hurkett
Red Rock
11+17
Thunder Bay
Lake Superior
0
20
50
Kilometers
▲ Indian Reserve
● Towns
■ Lac des Iles Mine
Roads
Railroad
Limit of 2003 bedrock mapping
Lakes

Figure 1. Map showing location of study area.

investment in high mineral potential areas in the region and adjacent areas; to provide a framework for informed future land use decisions; and to contribute to a geological synthesis of the region. The initiative includes bedrock mapping projects, airborne magnetic and radiometric surveys, ground gravity surveys, and targeted surficial geochemical and geochronological studies.

This report includes observations collected during field mapping conducted in 2004 as well as examination of the diamond drill core from a number of exploration holes located in the map area.

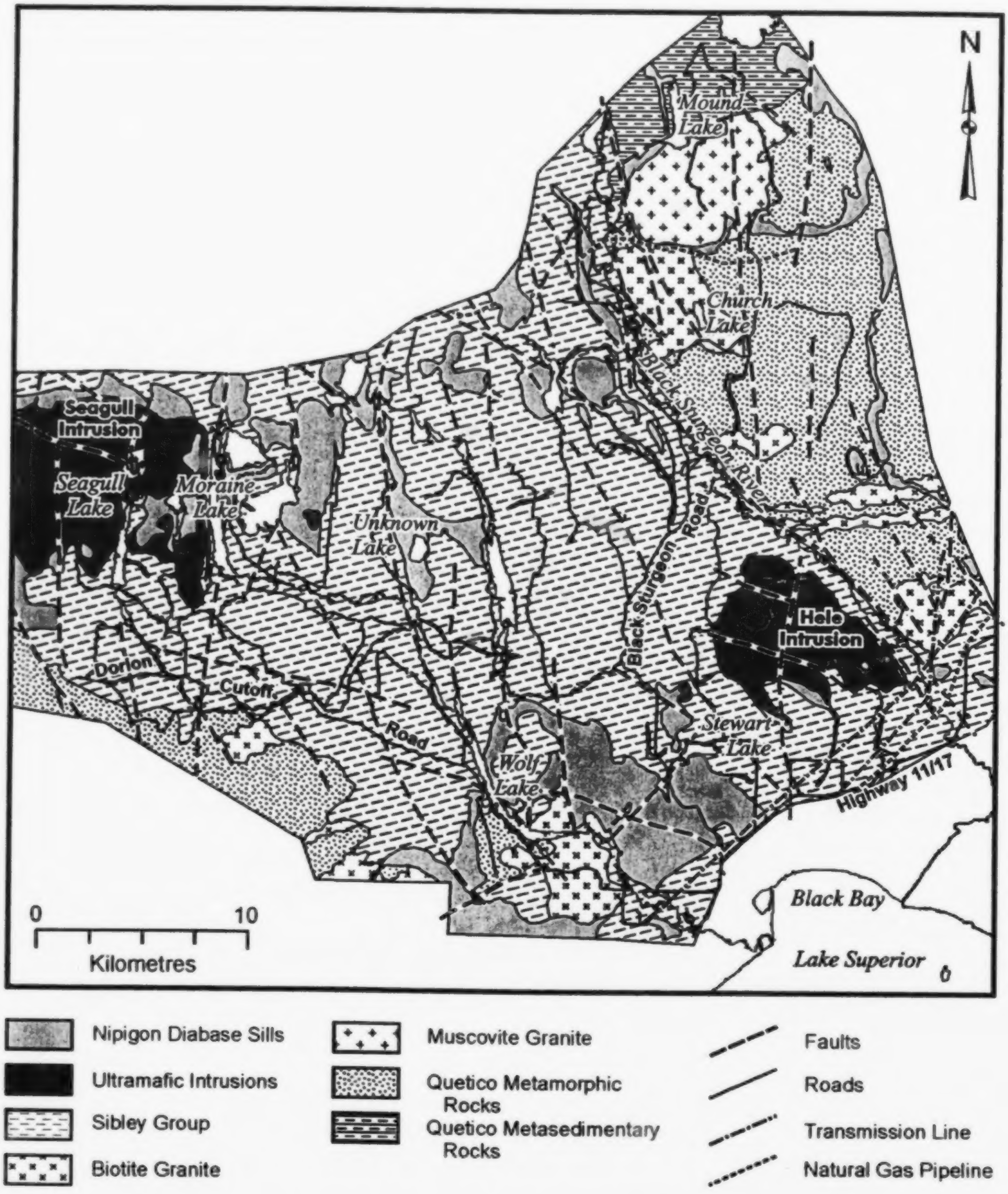
N
Mound Lake
Church Lake
Black Sturgeon River
Seagull Intrusion
Seagull Lake
Moraine Lake
Unknown Lake
Black Sturgeon Road
Hele Intrusion
Dorion Cutoff Road
Stewart Lake
Wolf Lake
Highway 11/17
Black Bay
Lake Superior
0
10
Kilometres
Nipigon Diabase Sills
Ultramafic Intrusions
Sibley Group
Biotite Granite
Muscovite Granite
Quetico Metamorphic Rocks
Quetico Metasedimentary Rocks
Faults
Roads
Transmission Line
Natural Gas Pipeline

Figure 2. General geology of the southern Black Sturgeon River and Seagull Lake map area.

Results of the airborne magnetic and radiometric surveys (Ontario Geological Survey 2004a), and the geochronological study completed as part of the LNRGI were also critical in the interpretation of the field data and geochemical analyses. Interpretation of project results was undertaken in co-operation with the Lakehead University partners (P. Fralick, P. Hollings, R. Metsaranta, A.J. Richardson and G.J. Heggie). An integral part of this report is the digital data contained in the Miscellaneous Release—Data (MRD) 147 (Hart 2005) that contains the lithogeochemical and assay analyses.

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The author was aided by senior assistant Alex Whaley, and by junior assistants Anthony Pace, Suzanne Halet, and Jessica Borysenko. Mr. Robert Middleton, East West Resource Corporation, allowed access to diamond drill core from the Seagull–Wolf Mountain property and provided background information for this map area and the Nipigon Embayment in general. Mr. John Scott, Resource Geologist, and Mark Smyk, Regional Resident Geologist, in the Resident Geologists' Office, Thunder Bay, provided background information on the mineral occurrences and the geology of this map area. Desmond Rainsford, geophysicist with the Ontario Geological Survey, provided assistance with images of the airborne magnetometer and gamma-ray spectrometer surveys, and a description of the survey parameters.

The use of a portion of the compound at the Dorion Fish Culture Station as a camp location and the old staff house as a field office, and the assistance of Mr. Paul Viera and the staff of the Dorion Fish Culture Station of the Ministry of Natural Resources was very greatly appreciated.

PREVIOUS GEOLOGICAL WORK

Previous geological mapping by Coates (1972) was completed in the northern portion of the map area at a scale of 1:63 360, and included interpreted geological sections. The south-central edge of the map area was previously mapped by McIlwaine and Tihor (1975a, 1975b) at 1:15 840 scale. A detailed examination of the intrusive rocks, Nipigon diabase sills and ultramafic intrusions of the Disraeli and Seagull–Leckie lakes areas, was completed by Sutcliffe (1986). A number of regional studies of the Sibley Group sedimentary rocks have encompassed the map area (e.g., Franklin et al. 1980; Cheadle 1986; Rogala 2003).

Exploration in the early 1900s resulted in discovery of lead and zinc mineralization and limited production from the Dorion Mine in 1903 (Shklanka 1969). The discovery of sporadic copper mineralization near Disraeli Lake, located north of the map area, in 1965, resulted in a surge in copper and the other base metals exploration in the late 1960s (Coates 1972). Exploration for uranium has been cyclical, with the greatest activity occurring in the middle to late 1970s coinciding with the discovery of large unconformity related deposits in other locations including the Wollaston Basin of Saskatchewan (Scott 1987). A number of companies are actively exploring for uranium mineralization at the time this report was being prepared. Several companies investigated the potential of sedimentary-hosted base metal mineralization in the Sibley Group in the early 1990s, but little of the work was recorded for assessment purposes. Exploration for platinum group element (PGE) mineralization intensified after the 1998 discovery of mineralization in the Seagull–Leckie Lake intrusion (Osmani and Rees 1998) and initial results of diamond drilling indicated the presence of a basal pyroxenite hosting up to 1.71 ppm Pt and 1.87 ppm Pd over 2.1 m (Durham 2000). Work completed in early 2004 has defined 2 zones higher in the intrusion with up to 1.52 ppm Pt and 1.78 ppm Pd over 3.0 m, and 1.56 ppm Pt and 1.87 ppm Pd over 3 m in the upper and lower zones, respectively (East West Resource Corporation 2004a, 2004b). Diamond drilling hole in late 2004 intersected 2.38 g/t Pt, 2.65 g/t Pd, 0.19 g/t Au, 0.18 g/t Rh, 0.39 g/t Os, 0.34 g/t Ir and 0.08 g/t Ru (Pd:Pt ratio of 1.11) associated 0.19% Cu and 0.20% Ni over 3.21 m (377.28–380.55 m; Platinum Group Metals Ltd., 2005).

Table 1. Lithological units for the southern Black Sturgeon River–Seagull Lake area.

- **PHANEROZOIC**
  - **CENOZOIC**
    - **QUATERNARY**
      - **RECENT**
        - Lake, stream and swamp deposits (unconsolidated)
      - **PLEISTOCENE**
        - Glacial deposits, sand, gravel, till (unconsolidated)

UNCONFORMITY

- **PRECAMBRIAN**
  - **PROTEROZOIC**
    - Mafic Intrusive Rocks (Nipigon Sills)
      - fine-grained to very coarse-grained diabase; magnetite-rich, coarse-grained diabase, with intergranular magnetite; very coarse-grained amphibole-plagioclase±potassium feldspar[a]; chilled diabase[b]; inclusion-rich chilled diabase[c]; dike; aplite with very fine-grained to aphanitic felsic rock cutting diabase sill
      - INTRUSIVE CONTACT
    - Mafic to Ultramafic Intrusive Rocks
      - peridotite[d]; olivine gabbro[e]; monzogabbro and/or granophyre[f]
      - INTRUSIVE CONTACT
    - Sibley Group Sedimentary Rocks
      - Kama Hill Formation
        - shale; siltstone; sandstone
      - Rossport Formation
        - mudstone; siltstone; dolomite; sandstone; carbonate breccia; stromatolitic carbonate; intraformational debris flow
      - Pass Lake Formation
        - sandstone
      - UNCONFORMITY
    - Diabase Dikes
      - diabase dikes (metamorphosed and weakly deformed)
      - INTRUSIVE CONTACT
  - **ARCHEAN**
    - Quetico Subprovince
      - Hornblende Suite
        - tonalite to granodiorite
        - INTRUSIVE CONTACT
      - Biotite Granite Suite
        - leucocratic granite[g]; dikes; feldspar megacrystic granite; massive; pegmatitic granite
        - INTRUSIVE CONTACT
      - Muscovite Granite Suite
        - muscovite-bearing granite[h]; muscovite and/or biotite granite; leucocratic granite
        - INTRUSIVE CONTACT
      - Biotite Tonalite Suite
        - dikes; granodiorite to granite
        - INTRUSIVE CONTACT
      - Gneissic to Migmatitic Suite
        - mafic gneiss[i]; leucocratic granite[j]; amphibolite[k]
        - INTRUSIVE CONTACT
      - Clastic Metasedimentary Rocks
        - feldspathic wacke; argillite; andalusite schist[l]; quartz-biotite-feldspar schist[m]; quartz-plagioclase-biotite±potassium feldspar schist
        - UNCONFORMITY
      - Mafic Metavolcanic Rocks
        - massive flow

Notes

[a] Amphibole may be either hornblende or actinolite; pink feldspar may be potassium feldspar or hematite-stained plagioclase. This unit could represent a late magmatic phase of the sills, assimilation of Sibley Group sedimentary rocks, or a combination of the two processes.

[b] Commonly polygonal textured and glassy if the plane of the contact is exposed.

[c] Biotite-rich matrix containing rounded xenoliths of older Sibley Group sedimentary rocks, Quetico Subprovince metasedimentary rocks, or quartz and feldspar xenoliths possibly the product of partial melting.

[d] Petrology indicates this unit includes wehrlite to lherzolite, dunite, and olivine websterite.

[e] Petrology indicates this unit includes olivine gabbro and olivine melagabbro; irregular contacts with the peridotite are ambiguous, and geochemistry suggests this unit is derived from the same magma source as the peridotite.

PRESENT GEOLOGICAL SURVEY

The southern Black Sturgeon River–Seagull Lake area was mapped during the summer of 2004 with geological field data recorded on a Hewlett–Packard iPAQ™ handheld computer using a relational database within the FieldWorker™ software. The data were downloaded daily to ArcView® for updating of the geodatabase and map. Geographic positions were recorded in Universal Transverse Mercator (UTM) projection and grid system, Zone 16, North American Datum 1983 (NAD83). These positions were obtained on a Garmin® GPS 76S™ global positioning system using an average of a minimum of 10 readings that usually allowed for a horizontal error of 5 to 7 m and a vertical error of approximately 15 m. In areas with a clear view of the satellites, a real time differential reading was obtained with an x–y error of less than 1 m, and a vertical error of approximately 3 m. The GPS positional data were compared with the digital elevation data obtained from the Ministry of Natural Resources, Ontario. The geological data were overlain on a digital base map at 1:20 000 scale derived from the Ontario Land Information Warehouse, Land Information Ontario, Ontario Ministry of Natural Resources.

Exploration information on assay results and diamond drill hole logs were obtained from the Earth Resources and Mineral Exploration web Site (ERMES) and the Assessment Files of the Residents Geologist office, Thunder Bay. Diamond drill hole locations were initially obtained from the diamond drill hole database in ERMES, with minor corrections applied based on examination of the assessment files. Mineral occurrence information was initially extracted from the Mineral Deposit Inventory (MDI2), and locations have been corrected based on data collected during the current mapping project, and examination of past geological mapping and assessment files.

General Geology

The southern Black Sturgeon River and Seagull Lake area is underlain by Archean rocks of the Quetico Subprovince that are unconformably overlain by Proterozoic sedimentary rocks of the Sibley Group (Table 1). Rocks of the Quetico Subprovince and the Sibley Group are intruded by Proterozoic mafic to ultramafic intrusive rocks in the Seagull Lake and Hele Township areas, in the northwest and southeast portions of the map area, respectively (*see* Figure 2). Mafic sills of the Nipigon diabase sill complex intrude all other rock types in the area.

Rocks of the Quetico Subprovince consist of biotite and/or andalusite schists that are gradually replaced towards the south by amphibolites. In the southern portion of the map area, a complex mixture of amphibolite or biotite gneisses and leucogranite have been classified as migmatite. A number of areas, mostly located east of the Black Sturgeon River, contain a high percentage of coarse-grained to pegmatitic irregular bodies and dikes of the muscovite granite suite (*see* Figure 2). Irregular bodies of medium- to coarse-grained rocks of the biotite granite suite intrude the amphibolites and, in the southern portion of the area, form the leucosome of the migmatitic rocks.

Notes for Table 1, continued

f Forms irregular pods within the olivine gabbro containing a pink feldspar that may be either a late magmatic phase or the result of assimilation of Sibley Group sedimentary rocks.

g May, in part, be part of gneissic leucogranite suite.

h Commonly contains graphic tourmaline-quartz intergrowths.

i Biotite schist, but may be, in part, fine-grained amphibolite.

j Mafic minerals compose <2% and may consist of biotite ± hornblende; forms irregular bodies within the gneiss and/or migmatites

k Massive to gneissic and, in part, composed of biotite.

l Metamorphosed and deformed greywacke and siltstone with remanent bedding and sedimentary textures.

m Metamorphosed and deformed greywacke and siltstone.

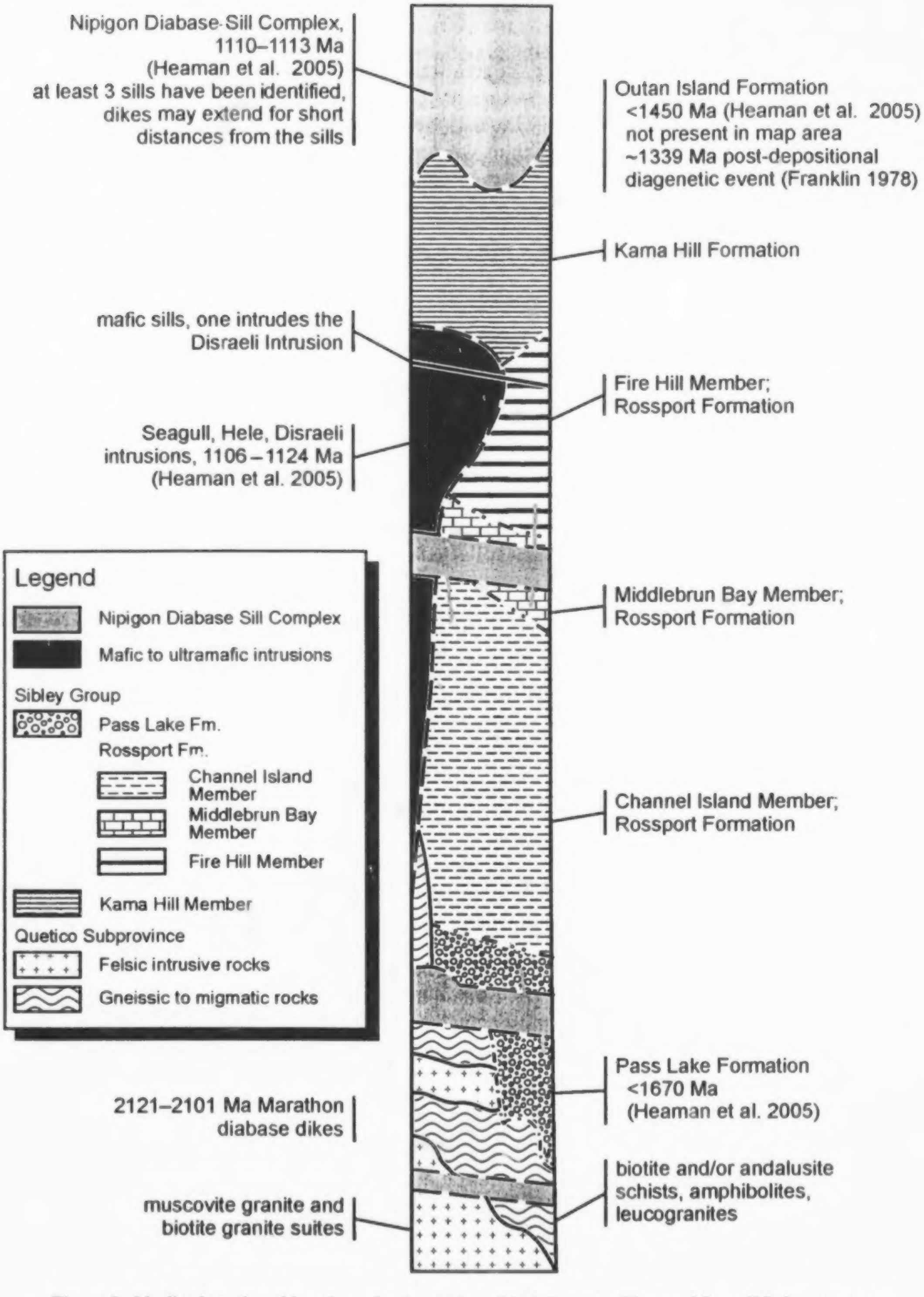

Nipigon Diabase-Sill Complex,
1110–1113 Ma
(Heaman et al. 2005)
at least 3 sills have been identified,
dikes may extend for short
distances from the sills
Outan Island Formation
<1450 Ma (Heaman et al. 2005)
not present in map area
~1339 Ma post-depositional
diagenetic event (Franklin 1978)
Kama Hill Formation
mafic sills, one intrudes the
Disraeli Intrusion
Fire Hill Member;
Rossport Formation
Seagull, Hele, Disraeli
intrusions, 1106–1124 Ma
(Heaman et al. 2005)
Legend
Nipigon Diabase Sill Complex
Mafic to ultramafic intrusions
Sibley Group
Pass Lake Fm.
Rossport Fm.
Channel Island Member
Middlebrun Bay Member
Fire Hill Member
Kama Hill Member
Quetico Subprovince
Felsic intrusive rocks
Gneissic to migmatic rocks
Middlebrun Bay Member;
Rossport Formation
Channel Island Member;
Rossport Formation
Pass Lake Formation
<1670 Ma
(Heaman et al. 2005)
2121–2101 Ma Marathon
diabase dikes
biotite and/or andalusite
schists, amphibolites,
leucogranites
muscovite granite and
biotite granite suites

Figure 3. Idealized stratigraphic column for the southern Black Sturgeon River and Seagull Lake map area.

Widely spaced, weakly deformed and metamorphosed, north-trending diabase dikes intrude the Archean rocks of the Quetico Subprovince. A paleomagnetic study by Ernst et al. (2005) of similar dikes located west of the area has interpreted these dikes to be part of the Paleoproterozoic (2121–2101 Ma) Marathon dike swarm.

The Proterozoic Sibley Group sedimentary rocks unconformably overlie the Archean rocks of the Quetico Subprovince, and rocks within the area have been subdivided into 3 relatively flat-lying formations, the lower Pass Lake, the middle Rossport, and the upper Kama Hill (e.g., Cheadle 1986) (Figure 3). The youngest U/Pb zircon ages of 1670 Ma, from detrital grains from a sandstone of the Pass Lake Formation, and 1657 Ma for a sandstone of the Nipigon Bay Formation (Heaman et al. 2005) represent the earliest possible deposition of the Sibley Group. The Outan Island Formation, which overlies the Kama Hill Formation and is, in turn ,overlain by the Nipigon Bay Formation, has the youngest U/Pb age for a detrital zircon grain (1450 Ma: Heaman et al. 2005), representing the youngest possible depositional age for the Sibley Group. A Rb/Sr age of 1339±33 Ma, based on analyses of a combination of Rossport and Kama Hill formation samples by Franklin (1978), probably denotes a post-depositional diagenetic event. The Pass Lake Formation is best observed in drill hole, and consists of conglomerate, quartz arenite, and minor dolomite, with rare outcrops of the upper sandstone members. The Rossport Formation consists of mudstone, dolomite, siltstone of the lower Channel Island Member, limestone and stromatolitic limestone of the Middlebrun Bay Member, and predominantly muddy variably carbonatized siltstone and mudstone of the upper Fire Hill Member (*see* Figure 3). Units of this formation are the most prominent sedimentary rocks in the area, particularly at lower elevations. The Kama Hill Formation is the uppermost formation of the Sibley Group exposed in the area and consists of laminated mudstone and siltstone with sandstone prominent in the upper section. This formation is exposed at the higher elevations across the area, west of the Black Sturgeon River.

Mafic to ultramafic intrusions occur in the Seagull–Leckie lakes and Hele Township areas (*see* Figure 2), and both are composed of a pyroxene peridotite core with an irregular olivine gabbro zone along the margin. A study of the Seagull intrusion indicates that it consists predominantly of cumulate-textured dunite, lherzolite, and olivine websterite, with minor olivine-hornblende pyroxenite (Heggie and Hollings 2004). An olivine gabbro is exposed in the upper and lower portions of many of the diamond drill holes, forming a border zone to the ultramafic rocks, and is the unit most commonly exposed in outcrop. Both intrusions have a monzogabbro phase occurring as irregular pods or bands distinguished from the olivine gabbro by the presence of abundant pink feldspar and minor amphibole. Samples from the Seagull intrusion have U/Pb ages from zircon and baddeleyite of between 1105 and 1124 Ma (L.M. Heaman, University of Alberta, personal communication, 2004). An olivine gabbro from the Hele intrusion has a U/Pb baddeleyite age of 1106±1.5 Ma with one fraction yielding a 1119.4 Ma age (L.M. Heaman, University of Alberta, personal communication, 2004). A diabase sill chilled against the olivine gabbro of the Seagull intrusion is exposed in a number of outcrops northeast of Seagull Lake and the intrusion is cut by a diabase sill in diamond drill core. An aphanitic dike of diabase cuts the olivine gabbro of the Hele intrusion in the area east of Driftstone Lake (*see* Preliminary Map P.3562).

A group of fine-grained, massive mafic sills, with a higher olivine content and distinctive geochemistry when compared to the ultramafic intrusions rather than the diabase sills, generally intrude the Sibley Group sedimentary rocks. Some of these sills are spatially associated with the ultramafic intrusions, as in the Moraine Lake and Hele Township areas, and probably represent extensions of the intrusions. In the Shillabeer Lake and Kama Hill areas, similar sills are not associated with known ultramafic intrusions and may be comparable to the Jackfish sills described by MacDonald (2004) in the English Bay area. One of these sills intrudes the Disraeli intrusion suggesting that some examples of this group postdate the larger ultramafic intrusions. This group of sills is difficult to distinguish from the diabase sills without petrography and lithogeochemistry.

A series of shallow-dipping Proterozoic diabase sills commonly form topographic highs as the sills are more resistant to weathering, and intrude all other rock units in the map area. The sills display a range of U/Pb zircon ages from 1110 Ma to 1113 Ma from sills located west of Lake Nipigon (Heaman et al. 2005). The diabase sills are commonly massive, medium- to coarse-grained feldspar and pyroxene with variable internal subdivisions not exposed in any one stratigraphic section. A generalized section of a sill from top to bottom would contain 1) chill, 2) fine-grained, variably amygdaloidal, 3) magnetite-rich, 4) medium- to coarse-grained, 5) coarse- to very coarse-grained, 6) fine-grained, variably amygdaloidal, and 7) chill. The amygdaloidal intervals are often absent and, when present, appear to correlate with the presence of a country rock that is high in volatiles. The sills range in thickness from less than 5 m to greater than 180 m and there appears to be at least 2 major sills greater than 100 m in thickness. However, erosion and block faulting hinders the correlation of the sills and, thus, the determination of the original number of sills.

Quaternary ice-marginal deltaic deposits of the Nipigon moraine form an extensive cover along the Black Sturgeon River and the area immediately to the west of the river (Barnett 2004). The rest of the map area further from the river is covered by differing thickness of till, which is reported by Barnett (2004) to be mainly locally derived.

The Archean rocks of the Quetico Subprovince vary from upper greenschist- to lower amphibolite-facies metamorphism, with limited areas of migmatite. Hornfels metamorphism, in zones up to 10 m wide, is variably developed in the Sibley Group where in contact with the peridotites, and occasionally the diabase sills. Solution cavities are common in the finer grained sedimentary rocks of the Rossport Formation and are commonly filled with gypsum and, in some areas, chert. Hematite and specular hematite is associated with some late fracturing in both Archean and Proterozoic rocks. The hematite appears to be a useful indicator of the north-trending fault systems in this area, where most structures are hidden by talus and glacial deposits.

Metasedimentary rocks of the Quetico Subprovince have experienced multiple phases of deformation. Schistosity is well developed along the bedding planes obscuring primary structures, but the rocks appear to be the metamorphosed equivalents of the greywackes and siltstones present in the Beardmore–Geraldton belt (Hart, terMeer and Jolette 2002). North- and northwest-trending regional fault trends have displaced the Proterozoic Sibley Group, and a northeast-trend may only represent minor late movement along previous Archean structures. The north- and northwest-trending faults define the Black Sturgeon fault zone, which has been interpreted to be *en échelon* resulting in the formation of a block-faulted asymmetric basin or graben (e.g., Coates 1972). There appears to have been little lateral displacement based on the correlation of the iron formations across Black Sturgeon Lake in the area north of the current map area. The north-trending faults are interpreted to be regionally continuous structures that may correlate with north-trending structures in the northern Gull Bay area. The northwest-trending faults display vertical movement with no apparent horizontal displacement, and may be traced to the west into the adjacent Wabigoon Subprovince. Accurate determination of displacements on these structures is not possible as they have been obscured by talus slopes and glacial deposits.

ARCHEAN

Clastic Metasedimentary Rocks

Metasedimentary rocks are exposed in the northeast corner of the map area, east of Black Sturgeon River (*see* Figure 2). These rocks consist of metamorphosed feldspathic wacke, lithic wacke, and siltstone that are metamorphosed to higher degrees progressively towards the south. The metawackes and metasiltstones are light greyish brown to medium grey, with 3 to 30 cm thick beds, and a schistosity parallel to bedding resulting in the variable preservation of original textures. These rocks commonly contain 5 to 10% biotite, trace to 1% very fine-grained garnet and, a trace subhedral mineral tentatively identified as cordierite. Specific bands are composed of individual to multiple beds contain 10 to 15% coarse- to very coarse-grained, subhedral to euhedral andalusite (Photo 1). The andalusite occurs disseminated through some beds and occasional concentrated along parallel bands that appear to represent the original bedding plane. This distribution probably reflects the distribution of clay minerals, with higher Al_2O_3 content, within the wackes. The andalusite schist is exposed in a band centred on Mound Lake and is not present further to the south (*see* Figure 2).

The metasedimentary rocks of this map area closely resemble the clastic metasedimentary rocks of the Quetico and Wabigoon subprovinces in the Beardmore area, east of Lake Nipigon (Hart, terMeer and Jolette 2002). For this reason, these rocks are interpreted to be the metamorphosed equivalents of the sedimentary rocks that accumulated in a trench environment of an accretionary complex comparable to the depositional environment of the Beardmore–Geraldton belt (e.g., Williams 1989).

Photo 1. Andalusite schist developed in preferentially along some bands in metawacke and metasiltstone of the Quetico Subprovince in the area west of Mound Lake (station 188.2). The size of the GPS unit is approximately 15.5 cm in length.

Photo 2. Chaotic mixture of amphibolite and leucogranite that may be classified as migmatite, east of the Black Sturgeon River (station 133.1). The hammer is approximately 37 cm.

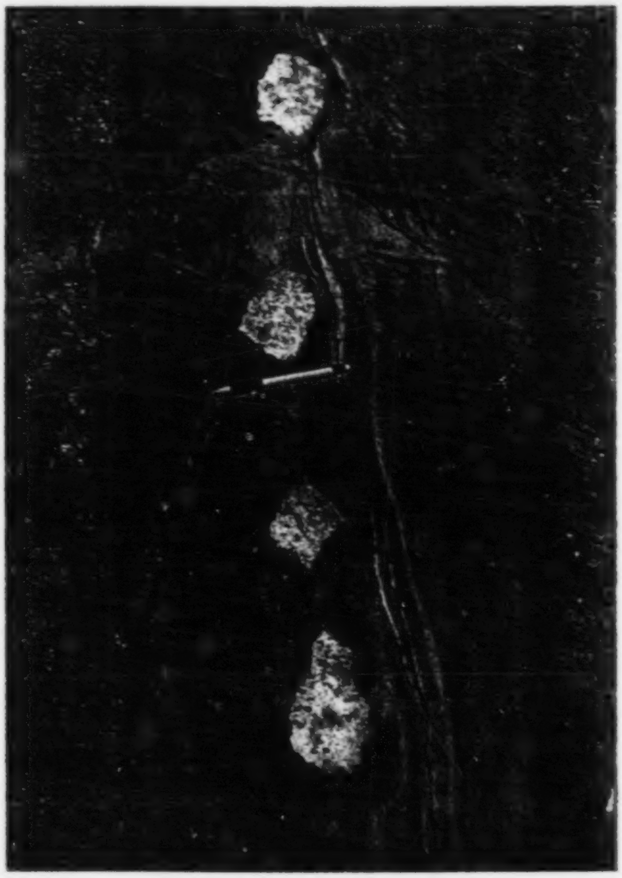


Photo 3. Boudinage of a leucocratic granite dike in amphibolite of the Quetico Subprovince along the Camp 42 Road, east of the Black Sturgeon River (station 99.1). The size of the pencil is approximately 15 cm.

Gneissic to Migmatitic Rocks

Deformation and metamorphic grades increase toward the south in the rocks of the Quetico Subprovince. Predominantly biotite schist and amphibolite are intruded by less amounts of felsic intrusive rocks with varied development of units that may be classified as migmatite in the area east of the Black Sturgeon River from Mound Lake south to the highway (*see* Figure 2). The biotite schist is a black to light grey rock composed of fine-grained biotite, plagioclase and quartz, and may be intruded along the schistosity by leucocratic dikes of the biotite or muscovite granite suites up to a few metres in width. The biotite schists are distinguished from the metasedimentary rocks to the north by the lack of any remnant depositional textures.

Transitions between the biotite schist and amphibolites are gradational, with possible enclaves of one rock type within the other, but the amphibolites are the dominant rock type in the southern portion of the map area. The amphibolite is a black to medium grey rock composed of fine- to medium-grained hornblende, plagioclase and quartz, with a variable weak to moderate foliation that, in some areas, may be classified as gneissic, although development of classic well-banded leucosome and melanosome gneissic textures is not common. Much of the area underlain by the gneiss rocks consists of domains of amphibole and domains consisting of a variable mixture of amphibolite and leucocratic quartz-feldspar granite dikes with gradual transitions between the two domains. The amphibolite and leucogranite domains may be classified as migmatitic and consist of irregular interbanding to chaotic mixtures of the two rock types that are common in both the southeast and southwest portions of the map area (Photo 2). In a few rare exposures, leucocratic dikes, 2 to 5 cm wide, are boudinaged, which suggests intrusion or formation early in the deformation event (Photo 3). The lack of well-developed gneissic textures, and the common occurrence of biotite schists and amphibolite xenoliths in the biotite and muscovite granite suite, suggests that these migmatites are a result of the intrusion of the felsic rocks rather than products of a migmatizing event associated with regional metamorphism.

Felsic Intrusive Rocks

The felsic intrusive rocks in the map area have been tentatively subdivided into 2 suites, biotite granite and muscovite granite suites, based on their field characteristics. The ages of these suites are not known and there is the possibility that they may be petrogenetically related. Both suites intrude the metasedimentary and gneissic rocks of the Quetico Subprovince, and are intruded by the Nipigon diabase sills.

The biotite granite suite occurs as irregular bodies and dikes in the area east of the Black Sturgeon River and in the southwest portion of the map area (*see* Figure 2). Rocks of this suite are light pinkish grey to light pink, massive, medium to coarse grained with rare very coarse grained to pegmatitic sections, and are composed of quartz and feldspar with typically less than 10% biotite. These rocks intrude, and commonly contain xenoliths of the biotite schists and amphibolites, with good examples exposed in the areas of southern Wolf Lake and north of Highway 11/17 east of the Black Sturgeon River (*see* Figure 2). The xenoliths are commonly a few metres in diameter and, in some locations, the presence of multiple xenoliths in a large-scale *lit-par-lit* texture suggests intrusion of the granite along the fabric of the pre-existing amphibolites, with good examples of this texture exposed along the east side of the Black Sturgeon River, north of the Camp 42 Road (*see* Preliminary Map P.3562). Very coarse-grained to pegmatitic pods and dikelets appear to cut the granite bodies and, in some cases, contain very coarse-grained magnetite (Photo 4), with the best examples located on Church Lake and west of the shaft of the Bishop Mine (*see* Preliminary Map P.3562).

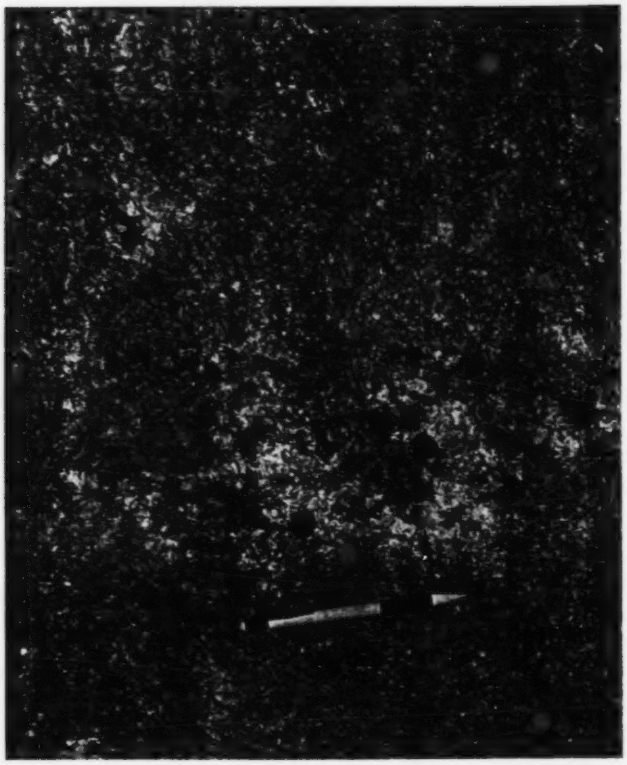


Photo 4. Very coarse-grained magnetite in a very coarse-grained to pegmatitic dike cutting a biotite granite on the west shore of Church Lake (station 298.1). The size of the pencil is approximately 15 cm.

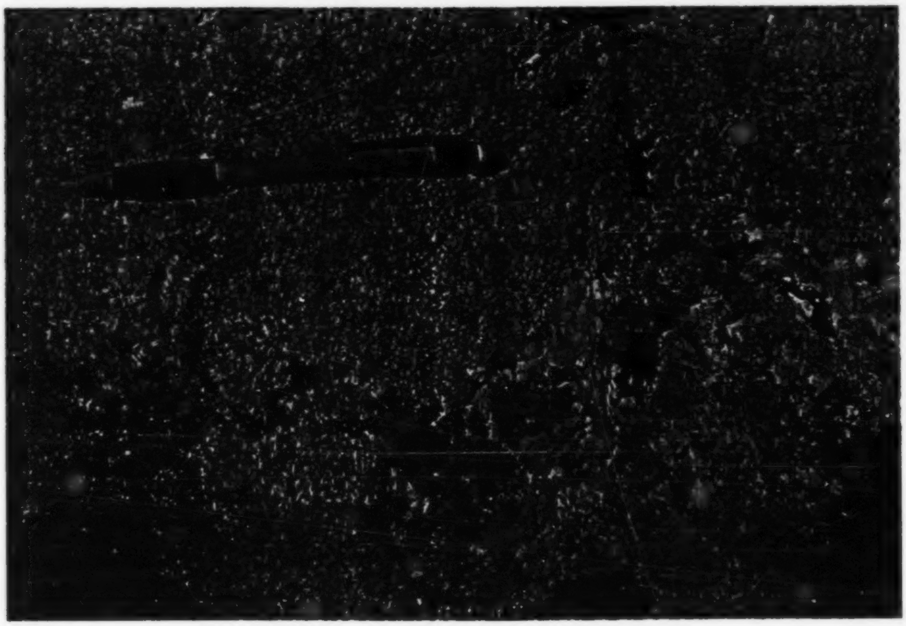


Photo 5. Tabular tourmaline and graphic tourmaline – quartz intergrowth in a pegmatitic pods within the muscovite granite body, south of Mound Lake (station 138.2). The size of the pencil is approximately 15 cm.

The muscovite granite suite occurs as a body located south of Mound Lake and as dikes intruding the metasedimentary and gneissic rocks to the north and south (*see* Figure 2). The body is light grey, pinkish grey, to white, massive, medium to very coarse grained with occasional pegmatitic sections, composed of quartz and potassium feldspar, and plagioclase with typically less than 5% muscovite. Irregular to tabular shaped xenoliths of metasedimentary and gneissic rocks up to a few metres in diameter are present throughout, but appear to be more common towards the margins of the body. Numerous muscovite granite dikes commonly a few metres wide, but locally up to a few tens of metres wide, intrude the massive body and the surrounding country rocks and may constitute up to 30% of the outcrop. The dikes are composed of pegmatitic quartz, potassium feldspar, and plagioclase and frequently contain graphic intergrowths of quartz and feldspar, black, coarse-grained to pegmatitic, tabular tourmaline usually graphically intergrown with quartz (Photo 5) and plumose intergrowths of muscovite-quartz. Trace to 1% fine-grained, disseminated, subhedral, reddish brown garnet, fine-grained light green mica or rosy quartz were identified in a few of the dikes. In the area along the Black Sturgeon River, southwest of Mound Lake (*see* Figure 2), a larger pegmatitic dike or body of granite displays irregular compositional layering (Photo 6) and possible igneous foliation of the potassium feldspar crystals. The lower mica content and variation in grain size along the strike length of the dikes hinders differentiation of the leucogranite dikes of the muscovite and biotite grain suites.

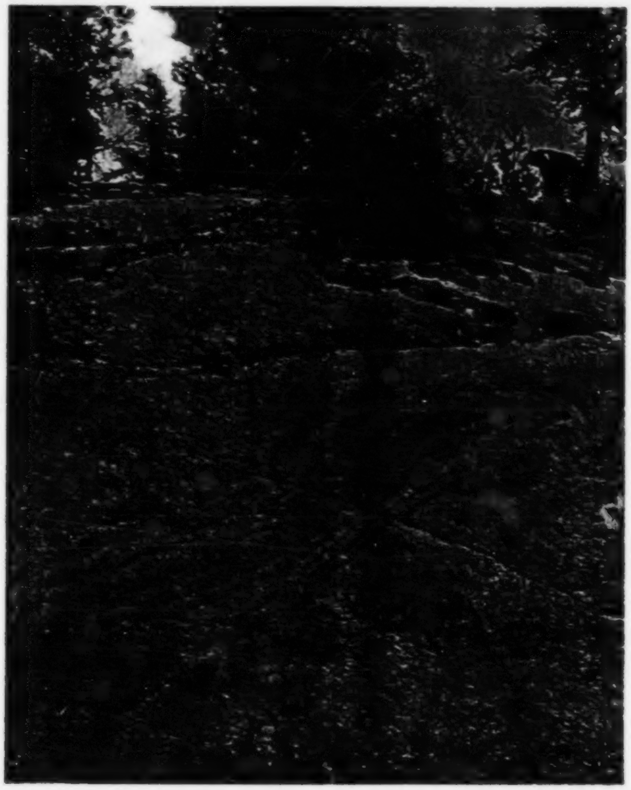


Photo 6. Compositional, igneous layering in a pegmatitic body of the muscovite granite suite east of the Black Sturgeon River (station 185.2). Reference scale is a person in the upper right of the photo.

PROTEROZOIC

Diabase Dikes

A north-striking, 3 to 5 m wide diabase dike intrudes the gneissic rocks in the area west of Wolf Lake (*see* Figure 2). The dike is medium to dark green, fine- to medium-grained, massive, gabbroic-textured rock with aphanitic chilled margins. A series of 2 to 3 cm wide bands of chlorite-filled vesicles are exposed in one outcrop, and may be the result of multiple pulse of magma. Chlorite and hematite alteration are present near the margins of the dike and in the surrounding country rocks, which forms an irregular 2 to 3 m wide alteration zone. The timing of the alteration is not known, but it may be related to the intrusion of the dikes. Similar alteration is associated with the diabase dikes in the Beardmore area (Hart, terMeer and Jolette 2002; Benedict and Titcomb 1947).

This dike resembles the dikes exposed in the area to the north mapped in 2003 (Hart and Magyarosi 2004a), and the dikes exposed to the west of the map area. The only difference being that those dikes are commonly plagioclase porphyritic, with white, subhedral, medium- to coarse-grained, disseminated plagioclase. A paleomagnetic and geochemical study of the dikes to the west of the map area suggests that the north-trending dikes are part of the Marathon dike swarm (2101–2121 Ma; Ernst et al. 2005).

Sibley Group Sedimentary Rocks

Proterozoic Sibley Group sedimentary rocks unconformably overlie the Archean rocks of the Quetico Subprovince, and rocks within the map area have been subdivided into 3 relatively flat-lying formations, the lower Pass Lake, the middle Rossport, and the upper Kama Hill formations (e.g., Cheadle 1986) (*see* Figure 3). The youngest U/Pb detrital zircon age for detrital grains from a sandstone of the Pass Lake Formation was 1670 Ma, and, with a 1657 Ma zircon age from a sandstone of the Nipigon Bay Formation (Heaman et al. 2005), represents the earliest possible deposition of the Sibley Group. The Outan Island Formation, which overlies the Kama Hill Formation and is, in turn, overlain by the Nipigon Bay Formation, had the youngest detrital zircon grain of 1450 Ma (Heaman et al. 2005), representing the youngest possible depositional age for the Sibley Group. A Rb/Sr age of 1339±33 Ma, based on analyses of a combination of Rossport and Kama Hill formation samples by Franklin (1978), probably denotes a post-depositional diagenetic event.

The lowermost unit of the Sibley Group varies with location as a result of tens of metres of topographic relief on the depositional paleosurface, as suggested by Cheadle (1986), and the few exposed basal units in the map area are Rossport Formation rather than Pass Lake Formation (*see* Figure 3). Sedimentation was probably locally controlled by these irregularities in the paleosurface on an outcrop scale, such that, although regionally the bedding is generally flat lying, bedding orientation on an outcrop scale may be highly varied. This local variation in bedding attitude complicates stratigraphic correlation (P. Fralick and B. Rogala, Lakehead University, personal communications, 2003). Irregularities in the paleosurface are pronounced in the area around Wolf Lake and, to the east of Wolf Lake, the basal rock types of the Sibley Group that are in contact with rocks of the Quetico Subprovince are siltstones and sandstones of the upper portion of the Channel Island Member. All of the Sibley Group formations are intruded by Keweenawan ultramafic intrusions and Nipigon diabase sills that result in weak deformation in some areas and a hornfels-facies metamorphism that appears to be more intense in rocks with an higher original carbonate content.

PASS LAKE FORMATION

The Pass Lake Formation consists of basal conglomerate and upward-thinning beds of quartz arenite, with minor dolomite beds (Franklin et al. 1980). The formation consists of a lower laterally discontinuous, clast- to matrix-supported conglomerate overlain by upward-fining sandstone to quartz arenite with minor thin interbeds of dolomitic mudstone and siltstone with a total thickness ranging from 0 to 100 m (Metsaranta, Fralick and Rogala 2003). This formation is generally very poorly exposed in the map area, and is best represented by the upper sandstones of the formation observed in diamond drill hole intersections. The 2 exceptions are an exposure in a stream bed along the road into Cavern Lake, and the sequence exposed at Moseau Mountain (*see* Preliminary Map P.3562). The stream bed exposure consists of mudstones and dolomitic cross-stratified siltstones that may be interpreted to be either an upper portion of the Pass Lake Formation (P. Fralick, Lakehead University, personal communication, 2004) or a lower portion of the Rossport Formation. At Moseau Mountain, cross-stratified sandstones of the upper portion of the Pass Lake Formation overlie rocks of the Quetico Subprovince, and are replaced upward by siltstone and mudstone of the Rossport Formation.

ROSSPORT FORMATION

The Rossport Formation disconformably overlies, or has a transitional contact with, the Pass Lake Formation (Metsaranta, Fralick and Rogala 2003), and is subdivided into the lower Channel Island, middle Middlebrun Bay and upper Fire Hill members (Cheadle 1986)(*see* Figure 3). Although every member of the Rossport Formation is present within the map area, the majority of the exposures are composed of the Channel Island Member with lesser amounts of the Middlebrun Bay and Fire Hill members. Nearly complete sections through the Rossport Formation have been exposed in a number of diamond drill holes, with the best example being HE02-02 located in Hele Township (*see* Preliminary Map P.3562, back pocket). The interpreted depositional environment for the Rossport Formation is a periodically flooded playa lake with a possible transition to a subaerial environment in the upper members of the formation (e.g., Cheadle 1986).

Estimates of the maximum thickness of the Rossport Formation vary from 134 m, at its type locality, to 300 m thick, north of the Town of Nipigon (Fralick, Smyk and Mailman 2000), with recent work by Rogala (2003) proposing an average thickness of 100 m. Cross-sections created for the area to the north of the map area, as part of the 2003 project mapping project (Magyarosi et al. 2004) suggest that the total thickness of the Rossport Formation may be up to 400 m, although the drill hole intervals on which this thickness is based contain approximately 300 m of diabase sill that may have lifted the sedimentary rocks; consequently, the original thickness is not accurately known (Magyarosi et al. 2004).

Clastic units of the Channel Island Member are commonly red to reddish brown siltstone and mudstone with reduction spots, solution cavities filled with gypsum and less commonly chert, and a pervasive weak dolomitization that diminishes upsection. The lower interbedded mudstone and siltstone of the cyclic facies are the dominant rock types in much of the southern portion of the map area, and contain 0.5 to 1.0 cm thick, light grey, pebbly sandstone beds that are best exposed to the west along the Dorion Cutoff Road (*see* Figure 2). The interbedded mudstones and siltstones are overlain by a cyclic facies of mudstone and dolomite, with the best example being exposed along the east shore of Wolf Lake under the diabase sill (Photo 7). Some of the dolomite beds may be sandstones with a dolomitic cement and, as noted by Metsaranta, Fralick and Rogala (2003), distinguishing between the two rocks types is often difficult. Most of the area north of the Dorion Cutoff Road and along the south-central portion of the map area consists of interbedded mudstone, siltstone and sandstone that overlie the cyclic mudstone (*see* Figure 2). The sandstones thicken upward through the sequence and Metsaranta, Fralick and Rogala

(2003) report that individual beds are usually cross-stratified, with tabular to occasionally channelized forms up to 3 m thick. These sandstones contain progressively less mud upsection, forming light reddish brown to white competent units that are resistant to weathering, and result in the formation of the Upper Falls on the Wolf River and Moraine Falls on Moraine Creek (*see* Figure 2; Photo 8; *see* Preliminary Map P.3562). The basal units that unconformably overlie rocks of the Quetico Subprovince in the area east of Wolf Lake are interbedded mudstone and sandstone of the upper Channel Island Member. The sandstone has a low mud content and contains angular pebbles of Archean rocks. Chert-filled solution cavities were commonly observed in the siltstones of the upper portion of this member, with the best examples along the logging roads immediately north of Moraine Falls (*see* Preliminary Map P.3562). Sand injection dikes, up to 10 cm wide, cut muddy siltstones of the upper portion of this member in 2 locations south of Moraine Creek (*see* Preliminary Map P.3562), and similar dewatering features have also been observed, by Metsaranta, Fralick and Rogala (2003), to form brecciated zones in overlying layers.

The Middlebrun Bay Member is a stromatolite facies in the middle Rossport Formation, which is not present in all areas, and is reported to be between 80 and 140 cm thick (Fralick, Smyk and Mailman 2000). Outcrops of stromatolitic limestone were observed in 2 locations: southwest of Moraine Lake and on the east side of the Black Sturgeon River in southeast Hele Township (*see* Figure 2). The outcrop southwest of Moraine Lake is light grey to white and predominantly contains stromatolites ranging from a few centimetres to a few tens of centimetres in diameter, with some of the large examples forming elongate ovoids up to 8 cm in length, with length to width ratios of 4:1. There are also abundant blocks of the limestone present in the area and these blocks generally contain stromatolites a few centimetres in diameter that are only slightly flattened ovoids (Photo 9). Cross-sections of the limestone exposed in

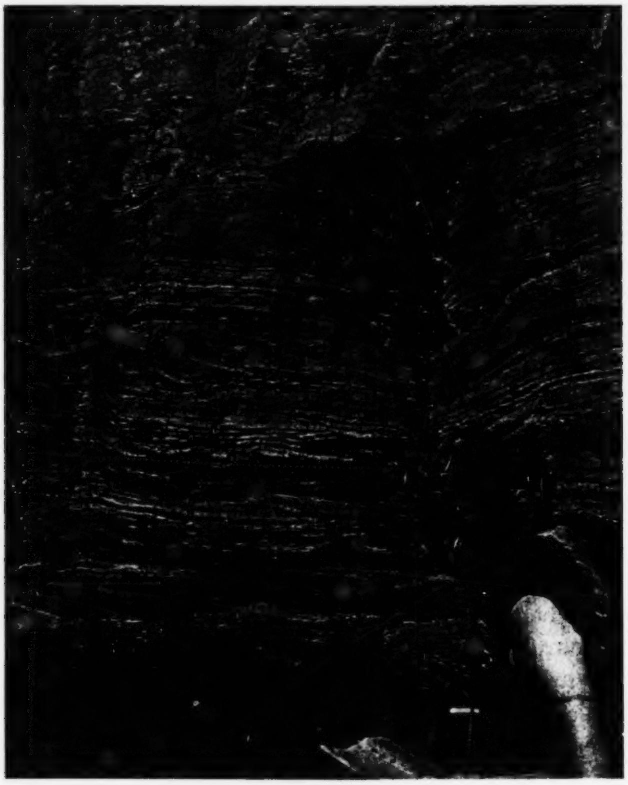


Photo 7. Weakly hornfels dolomite and mudstone of the cyclic facies, Channel Island Member of the Rossport Formation located on the east side of Wolf Lake (station 242.3).

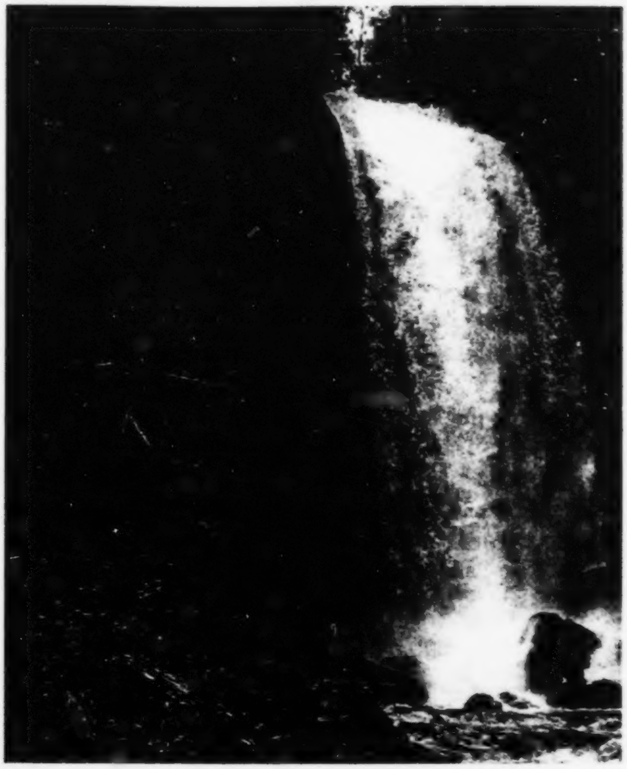


Photo 8. Siltstones and sandstones of the upper portion of the Channel Island Member of the Rossport Formation at Moraine Falls (station 1038). Reference scale is a person standing (centre) at the base of the falls.

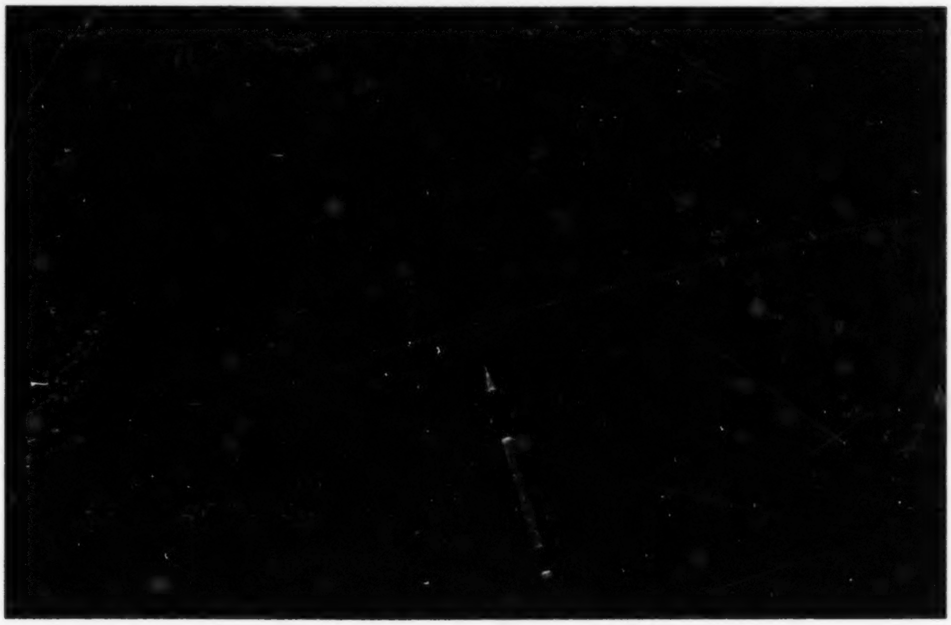


Photo 9. Stromatolitic limestone of the Middlebrun Bay Member of the Rossport Formation, located southwest of Moraine Lake (station 58.1). The size of the pencil is approximately 15 cm.

these blocks display well-developed, multiple mounds of finely laminated, domal light grey dolomite and chert, with some of the mounds extending for over a metre in length. Also present in the rubble are rare blocks of limestone containing 1 to 3 cm beds of black to dark grey finely laminated chert that, in some cases, appears to have been remobilized and forms the matrix to a limestone breccia (Photo 10).

A discontinuous intraformational conglomerate overlain by interbedded mudstone and siltstone form the Fire Hill Member of the Rossport Formation in the map area. An intraformational conglomerate and/or debris flow form the discontinuous unit at the base of this member, and is composed of subangular clasts of mudstone, siltstone, sandstone and dolomitic limestone, perhaps over 2 m thick, that appears to be matrix supported (Photo 11). The best examples are exposed west of Venice Lake, east of Wolf Lake and on the north end of the east Squaw Valley Road (*see* Figure 2). The conglomerate beds have been proposed to have formed either by dissolution of an evaporitic layer causing collapse of the overlying units, or tectonic raising of the basin margin resulting in the erosion and re-sedimentation in a more basin-centre environment of the upper marginal sediments with the latter interpretation favoured by Fralick, Smyk and Mailman (2000). The siltstones and mudstones are thinly bedded, red to light reddish brown to tan with reduction spots. Diagenetic gypsum and/or anhydrite nodules hosted by siltstone are report from diamond drill core (Metsaranta, Fralick and Rogala 2003). Franklin et al. (1980) report that the carbonate content decreases to nearly zero toward the top of the member. The best exposure of this member is in a cliff face along the Wolf River Road, and consists of finely interbedded laminated mudstone and cross-bedded siltstone with a variable reduction resulting in a mottled reddish brown to tan colouration that

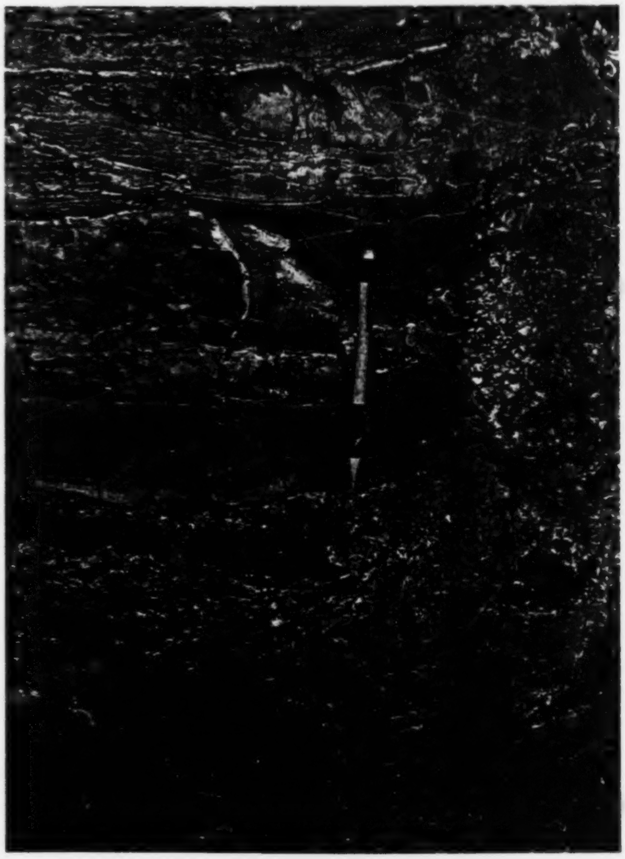


Photo 10. Black chert matrix to a stromatolitic limestone breccia in rubble located southwest of Moraine Lake (station 59). The size of the pencil is approximately 15 cm.

crosses bedding planes. Chaotic bedding higher in the cliff face may represent erosional collapse features (R. Metsaranta, Lakehead University, personal communication, 2004), and Metsaranta, Fralick and Rogala (2003) placed the transition between the Rossport and Kama Hill formations in the upper portion of the cliff.

KAMA HILL FORMATION

The Kama Hill Formation is generally restricted to higher elevations, particularly in the area west from Eagle Mountain to Seagull Lake (*see* Preliminary Map P.3562). This formation consists of laminated deep red to purple mudstone and tan siltstone, with lesser sandstone in the upper portions. This formation is best distinguished from the Rossport Formation by an absence, to near absence, of carbonate and the distinctive purple of the hematite rich mudstones. A bright red mudstone was observed in some locations, such as the upper portions of Eagle Mountain (*see* Preliminary Map P.3562), and has been interpreted to be a result of metamorphism by the diabase intrusion. In one location south of Unknown Lake (*see* Figure 2), interbedded mudstone, siltstone and sandstone contains collapse breccias composed of blocks up to a few metres in diameter. This exposure has been interpreted to represent a prograde deltaic sequence, located near the top of the Kama Hill Formation (P. Fralick, Lakehead University, personal communication, 2004).

An average thickness for the Kama Hill Formation was estimated by Rogala (2003) to be about 25 m. The interpreted depositional environment for the Kama Hill Formation is a distal alluvial floodplain in a shallow northwest-trending basin overlying the subaqueous playa lake sequence of the Rossport Formation (e.g., Cheadle 1986).

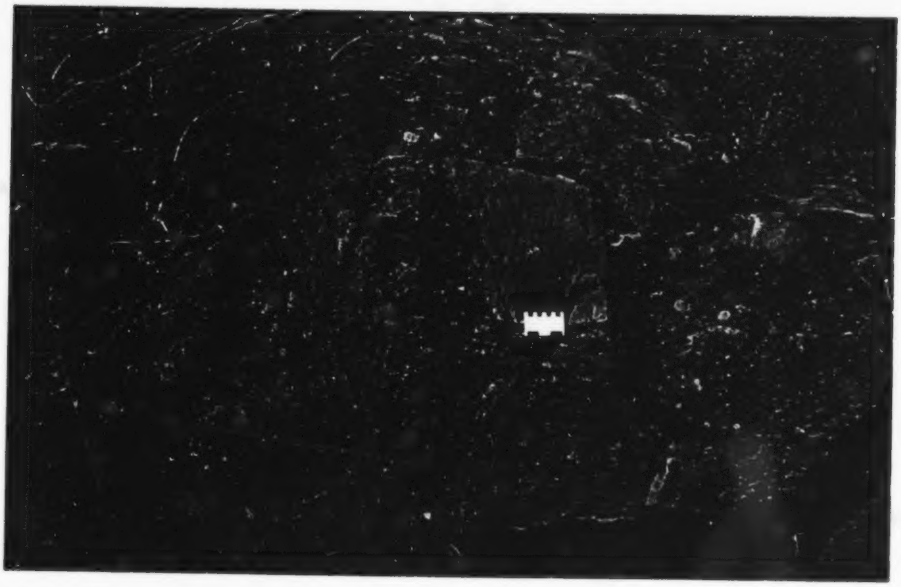


Photo 11. Intraformational conglomerate with angular clasts of Channel Island and Fire Hill members of the Rossport Formation located east of Wolf Lake (station 1209.1).

Mafic to Ultramafic Intrusive Rocks

Two ultramafic intrusions occur in the map area: one in the Seagull–Leckie lakes area and the other in southeast Hele Township (*see* Figure 2). These rocks intrude Sibley Group and Quetico Subprovince rocks and are, in turn, intruded by diabase sills. Both intrusions are composed of a pyroxene peridotite core with an irregular zone of olivine gabbro to olivine melagabbro and minor monzogabbro along the margins of the intrusions.

Samples from the Seagull intrusion have U/Pb ages from zircon and baddeleyite of 1105 to 1124 Ma (L.M. Heaman, University of Alberta, personal communication, 2004). Initial interpretation of this range of ages was attributed to an extended crystallization history, possibly due to multiple pulses of magma into the intrusion, but the lack of internal chill contacts suggests that there may have been another mechanism. An olivine gabbro from the Hele intrusion has a U/Pb baddeleyite age of 1106 to 1119 Ma (Heaman et al. 2005). A similar protracted crystallization history for the Hele intrusion was also proposed, but this intrusion is much thinner than the Seagull intrusion, which would not support a model of extended crystallization. A mechanism such as the assimilation of country rock rather than a protracted crystallization history is favoured to explain the ranges in age. A number of mafic sills up to a few metres in thickness are present in the map area, and may be lateral equivalents of the intrusions or possibly intrusions of a different age. A diabase sill chilled against the olivine gabbro of the Seagull intrusion is exposed in a number of outcrops northeast of Seagull Lake, and the intrusion is cut by a diabase dill in diamond drill core. An aphanitic dike of diabase cuts the olivine gabbro of the Hele intrusion in the area east of Driftstone Lake (*see* Preliminary Map P.3562).

SEAGULL INTRUSION

The Seagull intrusion covers an area of approximately 84 km^2 around Seagull Lake, and mapping has outlined discontinuous exposures of the intrusion extending the original limits of the intrusion to approximately 8 km southeast of the Seagull Lake (*see* Figure 2). The ultramafic portion of the Seagull intrusion is exposed in the northwest portion of the body, between Seagull and Leckie lakes. The intrusion has a maximum thickness of 730 m, estimated from diamond-drill holes, and most of this thickness consists of ultramafic rocks. The main rock type in the intrusion is pyroxene peridotite, which is medium to coarse grained, massive, often ophitic textured, composed of predominantly olivine and pyroxene with less than 10% plagioclase and 1 to 2% reddish brown mica resembling the Disraeli intrusion. Alteration, represented by serpentine, magnetite and minor biotite, occurs along fractures, which would account for the higher magnetic response of this unit in the airborne magnetometer survey. Intense hematization of the peridotite occurs in a number of highly fractured intervals in the diamond-drill core, and is interpreted to be related to regional structures that cut the intrusion (*see* "Alteration"). A diabase sill cuts the upper portion of the main body of the intrusion, but 2 smaller diabase sills were intersected in the most westerly drill hole (WM98-04).

The peridotite is described by Heggie and Hollings (2004) as consisting of cumulate-textured dunites, lherzolites and olivine websterite, with minor olivine-hornblende pyroxenite; scanning electron microscope, energy dispersive analyses of olivine, pyroxene, and oxide minerals throughout the intrusion show only minor variations in compositions. The best example is observed in the olivine compositions that are Fo_{80-89}, based on 737 analyses. An initial subdivision of the intrusion has been proposed, by Heggie and Hollings (2004), based on subtle variations in the rare earth element (REE) and high field strength elements (HFSE), into a basal unit, an overlying sub-main unit and a main unit. A thin section report, completed on samples from drill core, classified the ubiquitous interstitial mica as a phlogopite with up to 0.81 weight % Cl, and also identified a calcic amphibole with up to 1.2 weight % Cr_2O_3 and 0.18 weight % Cl (Taylor 2000).

During the current project, olivine gabbro to olivine melagabbro was mapped along the logging road access to the Seagull intrusion from the Dorion Cutoff Road to the south (*see* Figure 2). The gabbro is fine to medium grained, massive, dark green and composed of pyroxene and plagioclase with 15 to 20% olivine and trace to 1% reddish brown biotite. A leucocratic gabbro was observed in one location along the road and is complexly interfingered with the olivine melagabbro (station 52). The leucocratic gabbro contains up to 60% plagioclase that, in thin section, displays a higher than normal degree of alteration to sericite than much of the olivine gabbro. The contact between the olivine gabbro and peridotite is not exposed along this section of the road. During worked completed last year, the olivine gabbro and peridotite were observed to be complexly interfingered in the drill core along contacts that are generally gradual, with an apparent decrease in grain size from the peridotite to the olivine gabbro (Hart and Magyarosi 2004a).

Monzogabbro was observed in one outcrop, during the current mapping project, and was also observed in the upper portion of a number of diamond-drill holes (Hart and Magyarosi 2004b). It is fine to coarse grained and massive, with a variable amphibole content and a distinctive pink feldspar or groundmass. This rock type occurs as irregular bands or pods ranging from a few centimetres to a few metres in width with sharper contacts for the finer grained phases and gradual contacts for the coarser grained examples. The monzogabbro occurs close to the contacts between the intrusion and the country rocks.

HELE INTRUSION

Located in the southeast corner of Hele Township, the Hele intrusion covers approximately 40 km^2 and has a maximum thickness of 130 m, as defined by diamond drilling and the results of magnetic inversion modelling of the airborne magnetic data (*see* Figure 2). Peridotite is very poorly exposed in the central portion of the body, east of Driftstone Lake, and is interlayered with olivine gabbro and feldspathic peridotite in drill core. The peridotite is best exposed in an area of clear-cut logging, located on the northern edge of Stirling Township, as a high weathered and serpentinized rock with a high magnetic susceptibility (*see* Figure 2). The peridotite is dark green, medium to coarse grained, massive, variably ophitic textured composed of olivine and pyroxene with variable plagioclase and trace to 1% fine-grained reddish brown mica. Numerous, subparallel serpentine- and chlorite-rich fractures are common resulting in a banded or layered appearance to the otherwise massive peridotite. Contacts between the peridotite, feldspathic peridotite and olivine gabbro observed in diamond drill core are generally gradual transitions in grain size and olivine and plagioclase content. There appears to be more than one band of peridotite interlayered with the melagabbro and feldspathic peridotite suggesting internal subdivisions similar to the Seagull intrusion.

An olivine gabbro to olivine melagabbro forms much of the exposed area of the Hele intrusion, and is exposed along both the eastern and western access roads (*see* Figure 2). The gabbro is fine to medium grained, medium to dark green, massive composed of pyroxene, up to 30% plagioclase, and up to 40% olivine. Trace to 1% fine-grained, reddish brown mica is common in the olivine melagabbro of the central areas of the intrusion. An absence or very low abundance of mica and a lower concentration of olivine in the olivine gabbro forming the northern portion and margins of the intrusion means that it is difficult in distinguishing these rocks from the olivine-bearing diabase sills. The gabbro contains pods of monzogabbro in outcrop and is interbanded with monzogabbro is the upper portion of the diamond drill holes.

The monzogabbro is generally medium to coarse grained, massive with a varied amphibole content and distinctive pink feldspar or groundmass occurring in irregular shaped pods up to a metre in diameter. These pods are best exposed along the logging trails in the northeast portion of the intrusion hosted by medium- to fine-grained olivine gabbro containing minor pink feldspar. Less commonly, the monzogabbro is fine grained, massive reddish pink with minor quartz. This type of monzogabbro is present in irregular pods and dikelets with sharp contacts, with and without the coarser grained monzogabbro, in the western portion of the intrusion (Photo 12). Some of the best examples are in the central part of the intrusion, close to a small exposure of Sibley Group sedimentary rock that is in contact with the upper portion of the intrusion. In diamond drill core, the 2 types of monzogabbro are generally closely associated and, in some examples, the finer grained is rimmed by the coarser grained rock (Photo 13). The abundance of pink feldspar correlates with elevated K_2O values, and has been interpreted to be the result of the assimilation of Sibley Group sedimentary rocks (Hart and Magyarosi 2004a). The finer grained monzogabbro may be a poorly assimilated sediment xenolith and the coarser grained monzogabbro may be the result of assimilation of the volatile-rich sedimentary rocks.

MAFIC SILLS

A group of dark to medium green, fine-grained, massive mafic sills, with a higher olivine content and minor to abundant pink feldspar compared to the diabase sills, are generally observed to intrude the Sibley Group sedimentary rocks. Some of these sills are spatially associated with the ultramafic intrusions, as in the area southwest of Moraine Lake and Hele Township areas, and probably represent extensions of the intrusions. These sills have variolitic texture with a chilled margin composed of densely packed fine varioles and a core of coarse varioles in a very fine-grained matrix (Photo 14). This texture may be related to a more mafic sill intruding into the limestone horizon within the Rossport Formation, but a similar variolitic texture was also observed in a thin diabase sill cut by drill hole NI92-7 located west of Disraeli Lake. In other locations, the sills occur in areas without an associated ultramafic intrusion. A series of mafic sills, ranging in thickness from 0.5 to 3 m, intrude the Rossport Formation in the lower portion of section at Kama Hill, along Highway 17 (Hart 2003). In the Shillabeer Lake area north of this map area, 2 sills of more mafic composition were intersected in the upper portions of Bitterroot Resource Ltd. diamond drill holes 3, 4 and 5 (Richardson and

Photo 12. Monzogabbro as an irregular pod with sharp contacts with olivine gabbro, in the western portion of the Hele intrusion (station 1237.2). The size of the pen is approximately 16 cm.

Hollings 2005). The Shillabeer sills may correlate with mafic sills that cut the upper portion of the Disraeli intrusion in diamond drill hole D00-05, underlie the intrusion in hole D00-02, and were intersected in NI92-7 located to the west of Disraeli Lake (Hart and Magyarosi 2004b). The cross-cutting relationship in drill hole D00-02 suggests that some of these sills may be younger in age than the Disraeli intrusion. These sills may be comparable to the Jackfish sills described by MacDonald (2004) in the English Bay area. This group of sills is difficult to distinguish from a chilled or fine-grained diabase sill without petrography and lithogeochemistry.

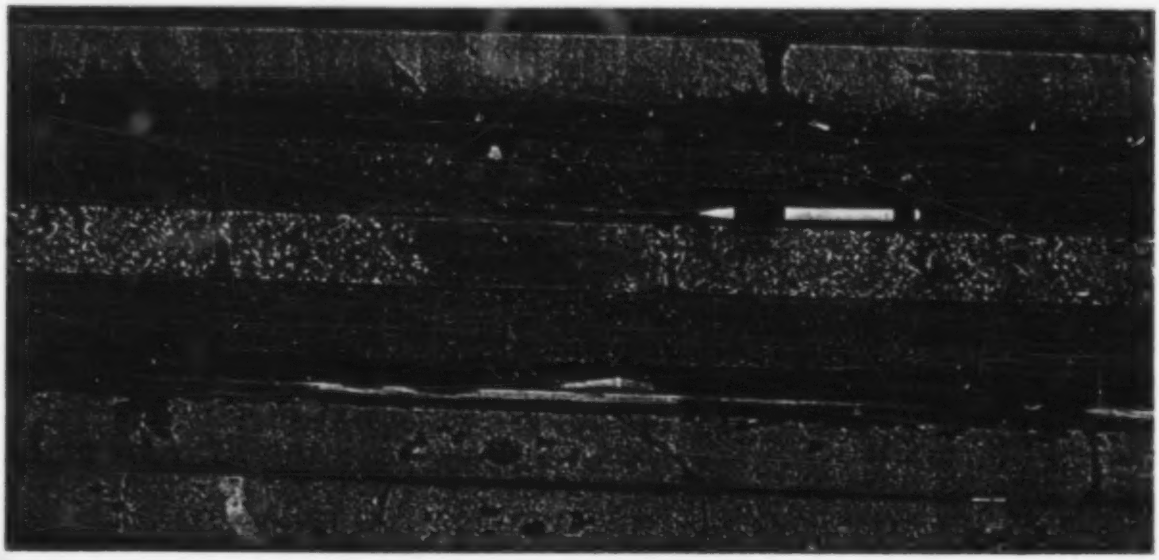


Photo 13. Fine-grained core of monzogabbro with a rim of coarse- to very coarse-grained amphibole , plagioclase and pink feldspar with fine-grained monzogabbro as interstitial material; Hele intrusion (HE02-01-15). The size of the pencil is approximately 15 cm.

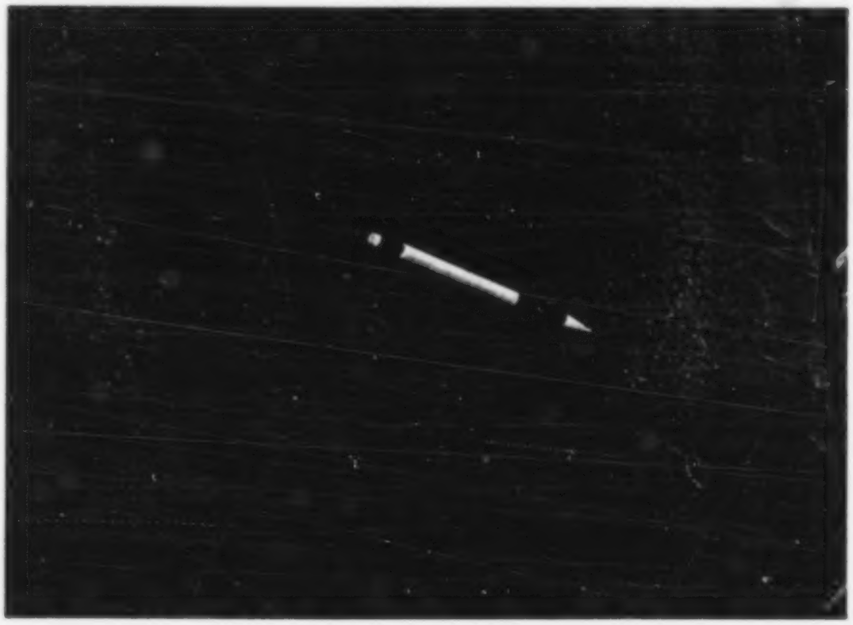


Photo 14. Variolitic textured mafic sill with densely packed fine varioles along the margins and coarse varioles in the core, chilled against Sibley Group sedimentary rocks (station 80.1). The size of the pencil is approximately 15 cm.

Nipigon Diabase Sill Complex

A series of generally flat-lying Proterozoic Nipigon diabase sills intrude all other rock units in the map area forming sills ranging in thickness from a few tens of metres to nearly 200 m. The sills display a range of U/Pb zircon ages from 1110 Ma to 1113 Ma from sills located west of Lake Nipigon (Heaman et al. 2005). In a few locations, 2 distinctly separate sills have been identified, which are separated by 0.30 to 20 m of Sibley Group sediment, with a good example of the sills exposed in the area south of Pringle Lake (*see* Preliminary Map P.3562). Previous mapping, completed in 2003, suggests that there may be 3 sills based on contact relationships in the Disraeli–Sturge lakes area (Hart and Magyarosi 2004a). There are no obvious textural or mineralogical differences between the sills that could be used as stratigraphic markers on a map or regional scale, and erosion and block faulting hinders the correlation of the sills and, thus, the determination of the original number of sills.

The diabase is commonly medium brown to brownish grey, massive, medium- to coarse-grained feldspar and pyroxene with trace to 3% olivine and 1 to 2% magnetite. Internal subdivisions in the sills are variably exposure and often difficult to recognize in outcrop, and are best represented in the diamond drill hole. A generalized section of a sill, from top to bottom, as described by Hart and Magyarosi (2004a), contains 1) chill, 2) fine-grained variably amygdaloidal, 3) magnetite-rich, 4) medium to coarse grained, 5) coarse to very coarse grained, 6) fine grained, variably amygdaloidal, and 7) chill. Medium- to coarse-grained diabase forms the majority of the sills and generally lacks a sub-ophitic or diabasic texture and should properly be classified as gabbro, but, to avoid confusion with other intrusions in the area, the diabase classification has been applied to all rocks associated with the sills. Some exposures of fresh, very coarse-grained diabase are exposed and commonly contain ophitic textures consisting of pyroxene oikocrysts up to 2 cm in diameter; a few exposures of very highly weathered exposures where the oikocrysts occur as pebbles were also observed. Magnetite-rich diabase is a field term that describes a diabase containing up to 15% magnetite that is the same grain size as the silicate mineral phases, in contrast to a generally smaller grain size, and occurs toward the top of the sills. The amygdaloidal intervals are generally absent or not exposed in this map area.

Photo 15. Layered diabase and leucocratic diabase near the upper contact of a sill located west of Abigogami Lake (station 1273). The size of the pencil is approximately 15 cm.

Layering is observed in a few outcrops that appear to be located close to the upper contact of a sill. The layers are highly variable in width, ranging from a few centimetres to more than 50 cm (Photo 15). The boundary between layers is generally marked by a decrease in grain size from medium to fine grained across a few centimetres and a higher percentage of feldspar. Layers appear to be flat lying to very shallowly dipping, possibly following the orientation of the overlying contact, but it is difficult to accurately determine the orientation of the layers due to the glaciated nature of the outcrops.

Pegmatitic diabase is common toward the sill contacts and consists of irregular patches or dikes of very coarse-grained white to pink feldspar and amphibole with occasional pink feldspar. The amphibole appears to vary in composition from hornblende to actinolite and may be up to 6 cm in length. Some pods may contain up to 30% pink feldspar that may be a potassium feldspar or hematite-stained plagioclase. The patches commonly have irregular outlines and may be up to 1.0 m diameter. This unit is equivalent to the pegmatoidal diabase described by Sutcliffe (1986). Hosted by medium- to coarse-grained diabase, the patches were interpreted by Sutcliffe (1986) to represent a late magmatic phase.

There are 2 general types of sill contacts that have been classified as chill and inclusion-rich chill. The most common type is an aphanitic to plagioclase porphyritic or glomeroporphyritic chill, a few centimetres in thickness that usually has a polygonal joint pattern if observed in plan view. They may have preserved glass and occasional subangular to subrounded, pebble- to boulder-size xenoliths of country rock (Photo 16). Reaction rims a few centimetres wide may occur around the xenoliths, particularly xenoliths of Quetico Subprovince rocks, but there is no other evidence of assimilation. Alteration is more common along joints in the chill contacts and may extend into the sills for up to a metre. Grain size in the chill zone increases to medium to coarse grained over a distance of less than a metre.

The inclusion-rich chill contact is relatively rare, and 2 styles of this contact type occur in the map area. The more common style is characterized by a fine-grained, massive, biotitic, occasionally plagioclase porphyritic diabase matrix containing abundant xenoliths containing angular to subrounded

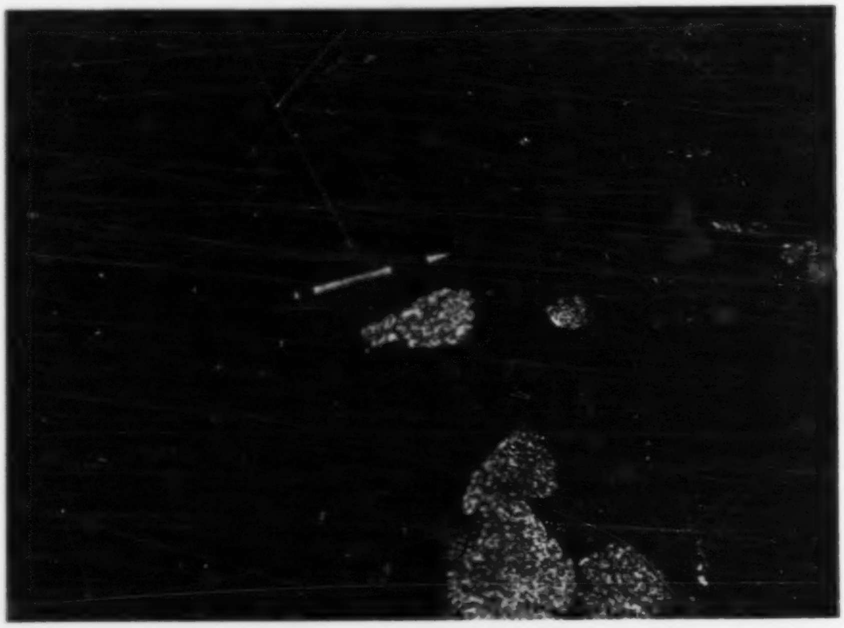


Photo 16. Glassy chilled diabase with rare glomeroporphyritic plagioclase containing granite xenoliths of the Quetico Subprovince, along the Camp 42 Road south of the Church Lake Road (station 145.3). The size of the pencil is approximately 15 cm.

CENTIMETRES

Photo 17. Fine-grained, massive, biotitic diabase matrix containing angular to subrounded pebble-sized xenoliths of coarse-grained quartz and white to pinkish feldspar, north of Highway 11/17 in Stirling Township (station 349).

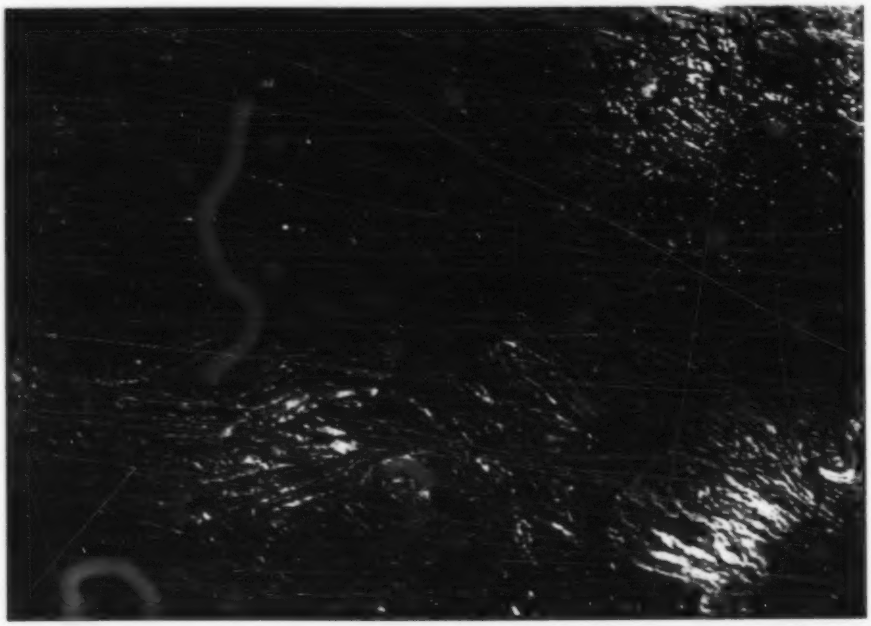


Photo 18. Very fine-grained diabase with xenoliths of light brown reduced Kama Hill Formation mudstones in the area west of Abigogami Lake (station 1069). The size of the pencil is approximately 15 cm.

pebble-size xenoliths of coarse-grained quartz and white to pinkish feldspar (Photo 17). The sill in the photograph has contact relationships exposed to the south along Highway 11/17 that indicate that it is intruding into calcareous sedimentary rocks of the Sibley Group. The volatile-rich composition of the country rock probably results in the formation of this contact type. However, a similar contact zone is present in a diabase sill intruding rocks of the Quetico Subprovince without any obvious evidence of Sibley sediments, about 10 km southwest of Beardmore, near the Warnesford Quarry on the CNR railway. This hybrid type of contact has been interpreted to be a result of the partial melting and assimilation of country rock forming xenoliths of quartz and feldspar restite and resulting in a biotite-rich diabase matrix. The second style was observed in one location where the diabase sill intruded into sedimentary rocks of the Kama Hill Formation. The matrix consists of a very fine- to fine-grained, dark grey green diabase with an irregular fabric suggesting a dynamic flow regime. The xenoliths appear to be reduced, light brown mudstone that varies from isolated angular blocks to aggregates of angular blocks that appear to be separating along the bedding surfaces (Photo 18). This outcrop is located close to an outlier of the Seagull intrusion and the mudstone may have been previously metamorphosed and deformed by that intrusion prior to the emplacement of the diabase. A greater diversity in this contact type was observed during mapping in the area to the north in 2003 (Hart and Magyarosi 2004a) and included a complex combination of gas cavities, very coarse-grained pods and a diverse mineralogical variation not observed in this map area. The absence of these textures probably reflects the lower degree of fresh exposures of the diabase in this map area as compared to the 2003 map area. Light green to grey green, medium-grained to aphanitic, 5 to 10 cm wide dikes cut the diabase in a couple of outcrops, and the dikes have been classified as aplites. One of the best exposures of these dikes is in an inclusion-rich chill zone, but their origin is not known.

Work completed last year indicates that coarse- to very coarse-grained diabase is more common toward the centre of the sills and has gradual contacts with the medium-grained diabase (Hart and Magyarosi 2004a). In drill hole SR02-01, there are multiple intervals of very coarse-grained, ophitic diabase in the lower portion of the sill interbanded with massive coarse-grained diabase that define a crude layering. This layering indicates a complex cooling history or injection of more than one phase of magma into the sills with the lack of internal chilled contacts suggesting emplacement of the pulse over a short time period.

Alteration

ARCHEAN ROCKS

Alteration in the Archean rocks of the Quetico Subprovince generally consists of weak to moderate hematite alteration restricted to narrow zones along fracture. The best example is disseminated hematite and fracture-fillings of specular hematite restricted to the contact zone of a north-trending diabase dike in the area southwest of Wolf Lake (*see* Figure 2). The hematite is generally closely associated with north-trending fractures; therefore, it appears to be a useful indicator of the north-trending fault systems in this area, where most structures are hidden by talus and glacial deposits (Hart and Magyarosi 2004a).

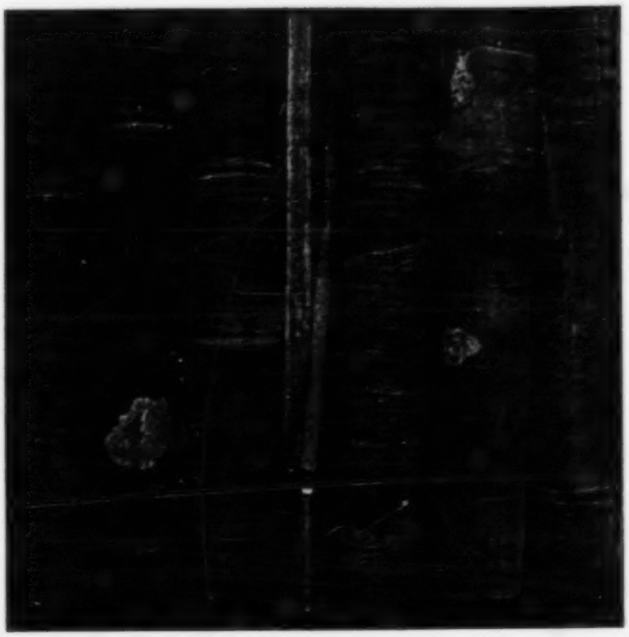


Photo 19. Solution cavities filled with gypsum in siltstones of the Rossport Formation underlying the Hele intrusion (HE02-02-117). The size of the pencil is approximately 15 cm.

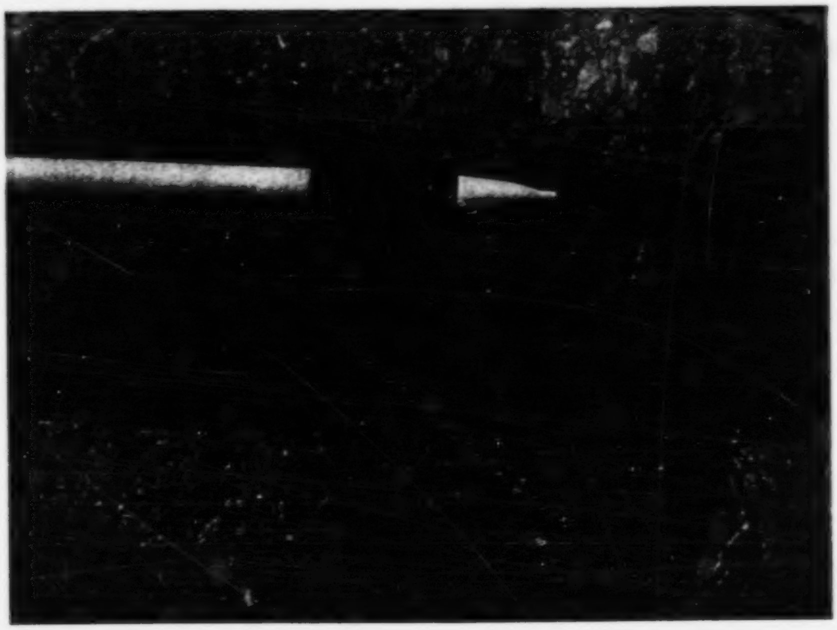


Photo 20. Reduction spots ranging from millimetres to a few centimetres in diameter with black cores in the smaller examples and black rings zoning the spots in the larger examples, Rossport Formation underlying the Hele intrusion (HE02-01-217). The size of the pencil is approximately 15 cm.

PROTEROZOIC ROCKS

Sibley Group

A number of features within the rocks of the Sibley Group are probably synsedimentary in origin and related to de-watering of the sedimentary pile. Irregularly shaped solution cavities up to a few centimetres in diameter are common in the mudstones and muddy siltstones of the Rossport Formation. These cavities may be filled with calcite, gypsum and/or light grey chert (Photo 19). In some areas, breccia up to a few centimetres in length, with gypsum and/or calcite matrixes, crosscut the bedding. These breccias may be similar in origin to the solution breccias described in other portions of the stratigraphy (e.g., Cheadle 1986).

Reduction of the normally oxidized Sibley Group may occur in a couple of different forms. Beige to light brown reductions spots are common in the red to reddish brown clastic sedimentary rocks of the Rossport Formation, and range in size from millimetres to a few centimetres in diameter (Photo 20). The smaller spots commonly have very fine- to fine-grained black cores and larger spots commonly have grey brown cores with black rings. Reduction of the clastic sedimentary rocks may also occur in irregular zones crosscutting the bedding and as haloes along fractures that range from a few millimetres in width, as seen in the right side of Photo 19, to a few tens of centimetres. Alteration of the sedimentary rocks as a result of the intrusion of the diabase sills and ultramafic intrusions varies with the formation. Light grey to grey brown zones of highly variable width occasionally occur along the intrusive contacts in rocks of the Rossport Formation, and are probably the result of variable reduction of the normally oxidized sedimentary rocks. One of the best examples was observed last year, in Bitterroot Resources diamond-drill hole DDH-3, where the reduction extends for approximately 3.5 m from the sill contact (Hart and Magyarosi 2004a). In rocks of the Kama Hill Formation, the normally purple mudstones may become a deep red along the intrusive contacts. Later hematite alteration, occurring as disseminated hematite and less commonly specular hematite, is sporadic and, when present, is commonly associated with late fracturing and is easily distinguished form the primary hematization of the sedimentary rocks.

Mafic to Ultramafic Intrusions

The peridotite and olivine gabbro of the Seagull and Hele intrusions have different weathering profiles and alteration effects primarily as a result of the differences in the olivine contents. The peridotite is commonly deeply weathered and may be capped by a black sand regolith tens of centimetres thick, and the peridotite outcrops are generally small and relatively rare with a very low relief. Serpentine alteration after olivine is generally moderate in the weathered zone and, although apparently restricted to fractures, the development of magnetite as a result of the serpentinization results in a high magnetic response in the airborne magnetic survey. Sets of parallel fractures are well developed in some sections of the peridotite resulting in a layered appearance, and commonly contain serpentine and chlorite with minor biotite and magnetite. Metre-scale zones of intense hematization occur in highly fractured and faulted portions of the peridotite of the Seagull intrusion, resulting in distinctive patchy dark-red appearance. A good example of the hematization occurs in diamond-drill hole WM98-04 located in the northwest part of the intrusion.

The olivine gabbro to olivine melagabbro is much more resistant to weathering and has a weathering pattern similar to the diabase, although it generally forms smaller and lower relief outcrops than the diabase. Alteration is usually restricted to minor development of chlorite along fractures. The presence and abundance of pink feldspar in the olivine gabbro, and the presence of monzogabbro, correlates with proximity to the contact between the intrusions and the Sibley metasedimentary rocks. Petrographic examinations indicate that the pink feldspar in monzogabbro is altered plagioclase with typical plagioclase twinning containing fine-grained dusting of possible hematite. Geochemical data indicates no apparent change in the iron contents associated with the pink feldspar, but there is commonly a higher K_2O content (*see* "Geochemistry"). Regardless, the monzogabbro is probably a product of assimilation of Sibley Group sedimentary rocks by the intrusions.

Nipigon Diabase Sill Complex

Weathering in the diabase is varied, ranging from less than 1 cm to 20 cm in depth. The depth of weathering appears to be controlled by factors such as outcrop exposure, grain size, and groundwater availability. The longer the diabase is exposed and the larger the grain size, generally the deeper it weathers and, in areas of recent road building, this may result in variable weathering patterns on a relatively homogeneous diabase.

Alteration of the diabase sills is generally restricted to joints and fractures, up to 5 cm in width, near the contacts with the country rocks. The fractures commonly contain coarse- to very coarse-grained amphibole and feldspar, rare medium-grained wollastonite and, commonly, have moderately chloritized diabase margins. A light pinkish grey alteration may occur along less than 0.5 cm wide cooling joints, for up to 1.0 m into the adjacent diabase, along some diabase–Sibley Group contacts. The adjacent metamorphosed Sibley Group rocks are commonly also a similar pinkish grey suggesting that joint filling may be a result of a combination of fluid migration and small-scale partial melting of the sedimentary rocks with minor melt migration. More commonly, the cooling joints in polygon contacts have a white alteration halo up to 1 cm in width, with the wider examples occurring where the diabase is in contact with the Sibley Group. This alteration may be an albitization of the diabase by fluids released from the sedimentary rocks.

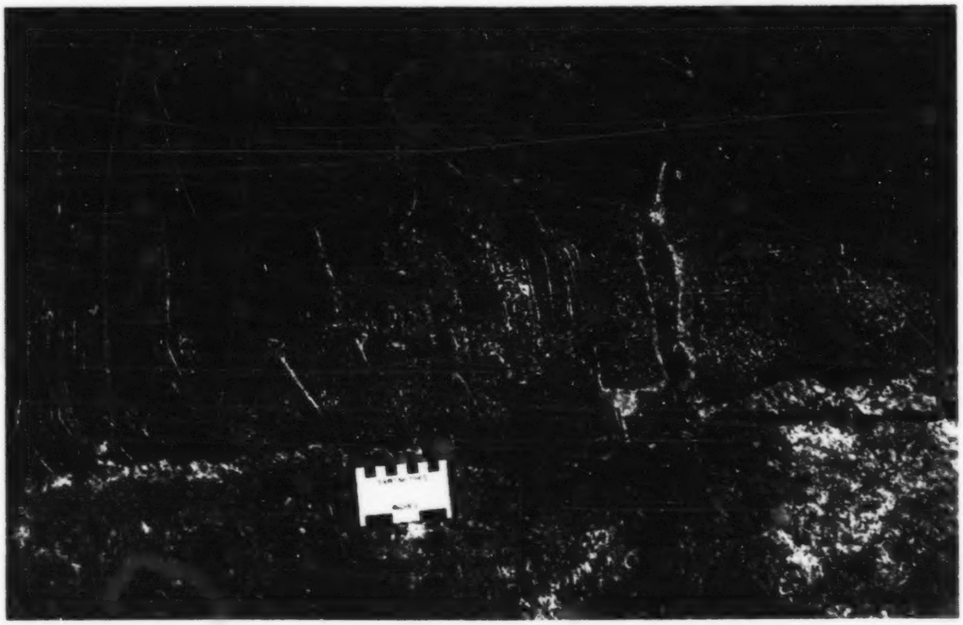


Photo 21. Tourmalinization of metawackes and metasiltstones as a result of the intrusion of a dike of the muscovite granite suite, southeast of Mound Lake (station 1149.3).

Metamorphism

Regional metamorphism in the rocks of the Quetico Subprovince ranges from lower greenschist to upper amphibolite, with higher degrees of metamorphism developed progressively to the south. The metawacke and metasiltstone, in the northeast portion of the map area, have some original sedimentary textures preserved. These rocks also contain 10 to 15% coarse- to very coarse-grained, subhedral to euhedral andalusite (*see* Photo 1) with minor cordierite suggesting a low-pressure, high-temperature metamorphic event possibly related to the emplacement of the felsic intrusion rocks. The andalusite pseudomorphs are at least partially replaced by a mica indicating some degree of retrograde metamorphism.

Metamorphic haloes associated with the felsic intrusions were not observed on an outcrop scale, suggesting that the metamorphic minerals grew during a regional event, rather than as a result of contact metamorphism. The exception is the tourmalinization of metawacke and metasiltstone in one location southeast of Mound Lake (*see* Figure 2). Very fine-grained black tourmaline, with associated quartz stringers, forms a halo extending up to 30 cm from the contact with a dike of the muscovite granite suite (Photo 21). The muscovite granite in this area commonly contain black tourmaline as tabular grains and as graphic intergrowths with quartz.

Higher metamorphic grades and deformation result in biotite schist and amphibolite replacing the andalusite schist to the south. Much of the Quetico Subprovince in the southern portion of the map area consists of domains of amphibole and leucocratic quartz-feldspar granite that could be classified as migmatitic. However, the lack of well-developed gneissic textures, and the common occurrence of biotite schist and amphibolite xenoliths in the biotite and muscovite granite suite (*see* Photo 2), suggest that these migmatites are a result of the intrusion of the felsic rocks rather than products of a regional metamorphic migmatizing event.

Sibley Group sedimentary rocks intruded by the peridotite, and occasionally the diabase, commonly develop a calc-silicate hornfels or skarn (Meinert 1992). The hornfels is variable in width extending up to 10 m into the sedimentary rocks adjacent to the intrusions and sills, although there is an approximately 60 m thick layer of sedimentary rocks between the 2 sills in diamond-drill hole ST02-01 that is variably metamorphosed throughout (Hart and Magyarosi 2004a). The mudstone beds commonly develop a light green, mauve, reddish grey to light grey banding. Dolomite-rich beds form light green, white to buff marbles probably dependent on the original mud content. Orbicular textures in 3 to 5 cm wide zones occur along some sill contacts, with the 0.2 to 0.5 cm orbs composed of radially oriented amphibole.

Sutcliffe (1986) identified 2 common assemblages of fine-grained, calc-silicate minerals: calcite-tremolite-forsterite (clinochlore) and calcite-diopside-forsterite at lower and higher metamorphic grades, respectively. The forsterite is altered to serpentine after forsterite. No dolomite and only minor quartz were observed. Rogala (2001) completed a study of interbedded mudstones and dolomites of the cyclic facies of the Channel Island Member and lower Middlebrun Bay Member of the Rossport Formation, intersected by drill hole NI92-5 located west of Disraeli Lake. These rocks contained a mineral assemblage of pargasite, tremolite, talc, clinochlore, calcite and barite with varying amounts of hematite and apatite, halite, sylvite, gypsum and dolomite. The halite and sylvite were interpreted to be a result of evaporite minerals present in the Sibley Group and the presence of these minerals probably controlled the formation of pargasite (Rogala 2001). The barite was interpreted to have been introduced into the Sibley Group by later fluid associated with the lead-zinc veining.

A good example of the hornfels occurs in a block of interbedded mudstone and dolomite surrounded by diabase and exposed along Highway 11/17 in east Stirling Township (*see* Figure 2). The eastern block appears to have been lifted, resulting in a westerly dip, by the diabase intruding underneath and from the east (Photo 22). However, the block is abruptly truncated by a vertical contact to the west, and a less than 25 cm thick sill intrudes along the bedding eastward from this contact. The ambiguity of the injection direction of the diabase may be a result of the rock cut being an oblique to the injection direction, and the block may not be totally separated from the surrounding Sibley Group. The western block is chaotic with no preservation of bedding and is probably a detached, deformed and metamorphosed xenolith. Metamorphism in the sedimentary rocks decreases away from the contact, and the sedimentary rocks close to the contact contain an assemblage of diopside, phlogopite, clinochlore, pargasite and calcite.

Photo 22. A block of hornfels Sibley Group sedimentary surrounded to the east, west and along the top by diabase (station 350).

Photo 23. Irregular zones and clasts of quartz and microcline in the calc-silicate hornfels along the contact with the diabase sill (station 350.4). The size of the pencil is approximately 15 cm.

In some areas along the contact, there are irregular zones to isolated pebble-size clasts of quartz and microcline within the calc-silicate hornfels (Photo 23). The quartz and microcline may represent a partial melt of the sedimentary rocks by the diabase.

Wollastonite, NaCa-zeolite minerals, actinolite and/or tremolite, chlorite and feldspar occur along joints and fractures in the diabase sills near contacts with Sibley Group. These minerals may have formed as a result of reactions with the sedimentary rocks, although they may, in part, be related to a later hydrothermal event.

Calculations by Sutcliffe (1986) suggested that the diabase sills were emplaced at shallow crustal levels, at a lithostatic load of between 0.06 and 0.43 kilobars. The sills were estimated to have crystallized over a temperature range of 1100 to 800°C, over a 315 to 560 year period for a 150 to 200 m thick sill. Adjacent wall rocks were estimated to have reached 665°C and the metamorphic mineral assemblages suggest temperatures of above 540°C.

Geochemistry

A suite of 156 samples was analyzed for major, trace, and rare earth elements plus Au, Pt, and Pd (*see also* Hart 2005 (MRD 147): geochem2004.xls). This suite includes a combination of samples from outcrop and from diamond drill core for the Hele intrusion, the diabase sills, Sibley Group sedimentary rocks, and rocks from the Quetico Subprovince (Figure 4). These analyses have been integrated to only a limited extent in the current map and report due to time limitations. Included in this data set are 18 samples analyzed by the nickel fire assay–inductively coupled plasma mass spectrometry (ICP–MS) method for the platinum group elements (PGE) and 4 samples analyzed for Se and Te.

A suite of 45 samples collected during 2003 were included for PGE analyses by the nickel fire assay–ICP–MS method, and include 14 samples from a diamond-drill core analyzed for A.J. Richardson as part of a MSc thesis being completed at Lakehead University (*see also* Hart 2005 (MRD 147): geochem2003.xls). Eight of these 45 samples also had Se and Te analyses completed. A suite of 10 samples included in this table are 2003 samples for which analytical work was completed in 2004 to provide additional information on the chemistry of the Sibley Group and metasedimentary rocks of the Quetico Subprovince.

A suite of 52 samples was collected during a reconnaissance sampling project during the 2002 field season (*see also* Hart 2005 (MRD 147): geochem2002b.xls), and the results have been discussed in previous publications (e.g., Hart 2003). In addition to material collected within the limits of the 2004 mapping project, this table includes samples collected from the Kama Hill area and south along Highway 11/17 toward Thunder Bay. Three of the Kama Hill mafic sills were analyzed for PGE by the nickel fire assay–ICP–MS method.

Analytical work was completed at the Geoscience Laboratories of the Ministry of Northern Development and Mines, in Sudbury, Ontario (*see also* Hart 2005 (MRD 147)). The major element and select trace element analyses were completed by X-ray fluorescence using fused glass disks and press powder pellets, respectively. Carbon dioxide and sulphur were analyzed by infrared spectroscopy. The rare earth elements (REE) and other trace elements (tantalum, thorium, uranium and niobium) were analyzed by inductively coupled plasma mass spectrometry (ICP–MS) from a closed-beaker digestion. Other trace elements and base metals were analyzed by inductively coupled plasma atomic emission spectroscopy (ICP–AES). All samples were analyzed for precious metals by ICP–AES.

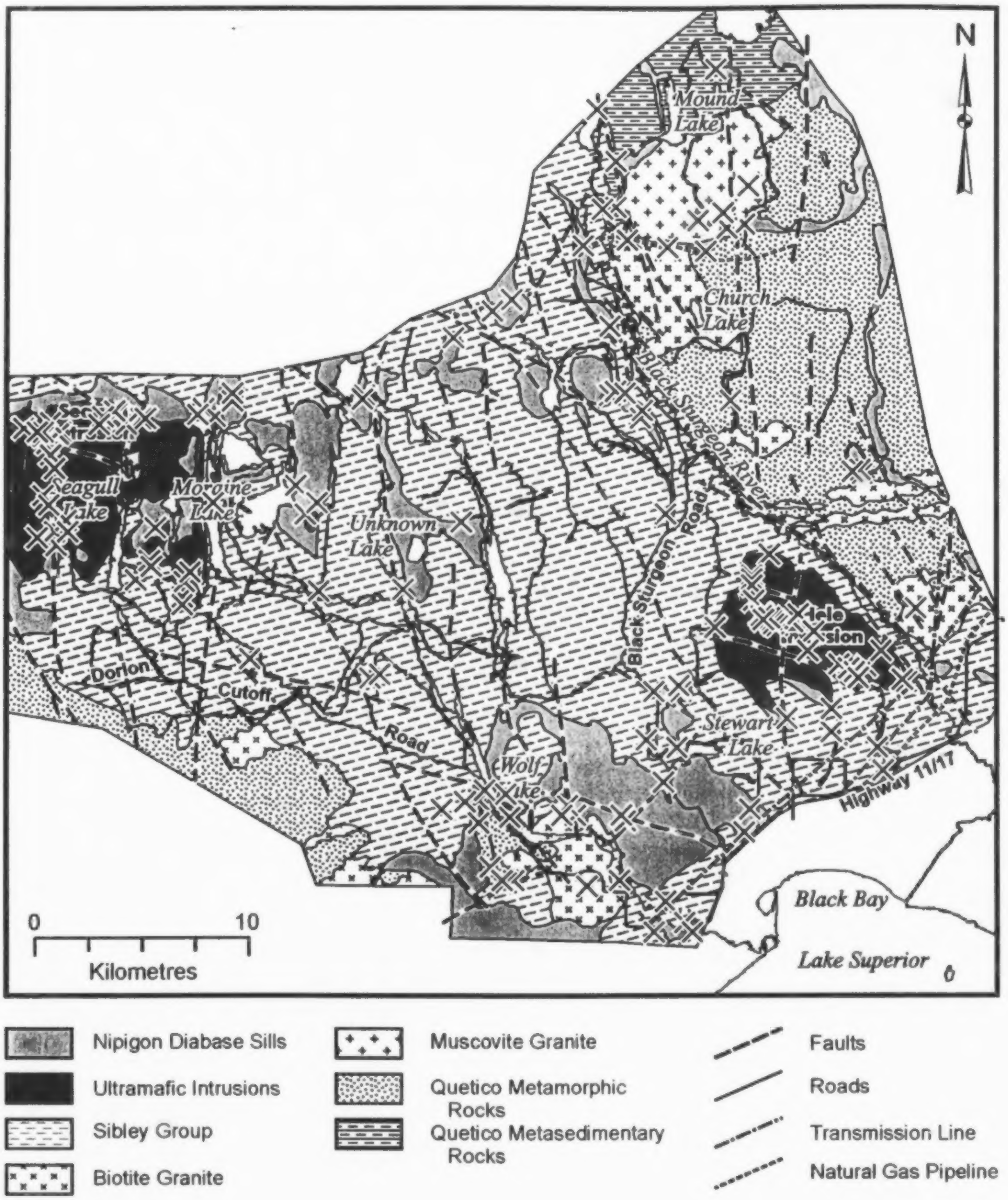

N
Mound Lake
Church Lake
Black Sturgeon River
Seagull Lake
Moraine Lake
Unknown Lake
Black Sturgeon Road
Dorion Cutoff Road
Wolf Lake
Stewart Lake
Highway 11/17
Black Bay
Lake Superior
0
10
Kilometres
Nipigon Diabase Sills
Ultramafic Intrusions
Sibley Group
Biotite Granite
Muscovite Granite
Quetico Metamorphic Rocks
Quetico Metasedimentary Rocks
Faults
Roads
Transmission Line
Natural Gas Pipeline

Figure 4. Distribution of lithogeochemical samples collected in 2004 and 2002 in the southern Black Sturgeon River map area (details contained in MRD 147).

MAFIC TO ULTRAMAFIC INTRUSIVE ROCKS

Hele Intrusion

Geochemistry suggests that the Hele intrusion may be subdivided into olivine gabbro, olivine melagabbro, and peridotite. Elemental variations in the diamond-drill core samples appear to indicate that the Hele intrusion is composed of more than one pulse of magma, producing a layering of the peridotite and melagabbro. The peridotite has higher MgO contents, up to 29.47 weight %, and follows a trend indicating that fractionation was controlled by olivine and clinopyroxene (Figure 5). The olivine melagabbro has MgO contents of between 11 and 17 weight %, and follows a fractionation trend indicating a change from control by olivine and clinopyroxene crystallization to control by plagioclase and clinopyroxene. The olivine gabbro has MgO contents of less than 11 weight %, and follows a trend controlled by plagioclase and clinopyroxene fractionation (*see* Figure 5). Total rare earth element (REE) and high field strength (HFSE) concentrations in the peridotite samples are generally lower than in the olivine gabbro or olivine melagabbro (Figure 6). All of the rocks have weak negative TiO_2 and Zr anomalies on the mantle-normalized extended element diagram (*see* Figure 6), and these anomalies are more pronounced than negative Nb and Ta anomalies for the Seagull and Disraeli intrusions (Hart and Magyarosi 2004a), although all 3 intrusion have flattening of the trends between Th and La. All 3 units have $[La/Yb]_{mn}$ (mantle normalized) and Gd/Yb ratios that are distinctly higher than the diabase sills, and plot toward the high end of the field defined by the Lower Suite of the Osler Group volcanic rocks (Figure 7). Rocks of the Hele intrusion have a wider range of Gd/Yb ratios that the rocks from the Disraeli and Seagull intrusions, but overlap with the values for the other intrusions.

The peridotite and gabbro are not enriched in nickel, and the peridotites follow an olivine-controlled igneous fractionation trend, which would be consistent with a parental MgO concentration of approximately 13 weight % (Figure 8). The peridotite and olivine gabbro have similar PGE contents with Pt/Pd ratios of 1.03 to 4.63 with the highest values being 75.87 ppb Pt, 50.24 ppb Pd and 24.07 ppb Au in an olivine gabbro. Both units have a flat positive slope on a primitive mantle-normalized PGE diagram with enrichment in Ir and Pt (Figure 9), compared to the trends for the diabase sills that follow a trend similar to that of most continental flood basalts (Hart, terMeer and Jolette 2002). The peridotite and olivine gabbro have similar base metal contents with 18 to 1320 ppm Ni, 17 to 459 ppm Cu, and 72 to 280 ppm Zn.

Pink feldspar may occur as a minor mineral phase in the olivine gabbro, and is a major constituent of the monzogabbro, or granophyre (*see* "Mafic to Ultramafic Rocks"). The presence of pink feldspar usually correlates with higher K_2O content, that may be up to 7.42 weight %, with no appreciable change in the Fe_2O_3 contents compared to the other olivine gabbro. Although the high K_2O is possibly related to late stage igneous fractionation, it is considered more likely that these values are a result of assimilation of Sibley Group rocks and that the pink colour is a result of potassic alteration rather than hematization. The peridotite and olivine gabbro have REE and HFSE ratios that are comparable to ocean island basalts and most of the rocks from the Disraeli and Seagull intrusions in contrast to the diabase sills (Figure 10).

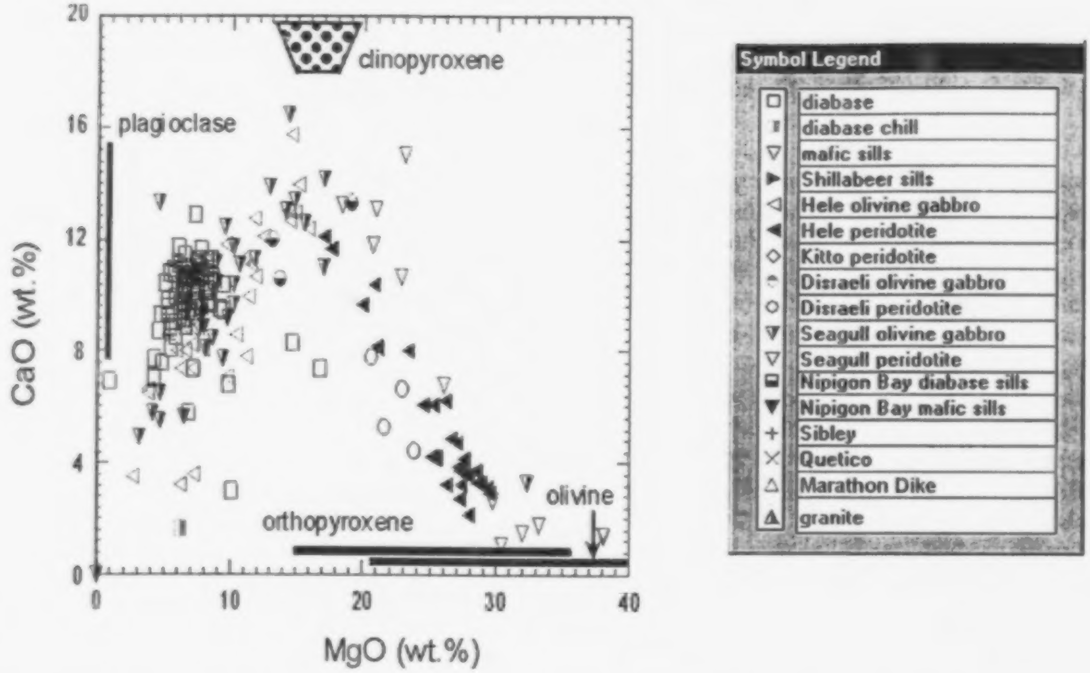


Figure 5. MgO versus CaO diagram of the mafic to ultramafic intrusive rocks and Nipigon diabase sill complex (*after* Sutcliffe 1987).

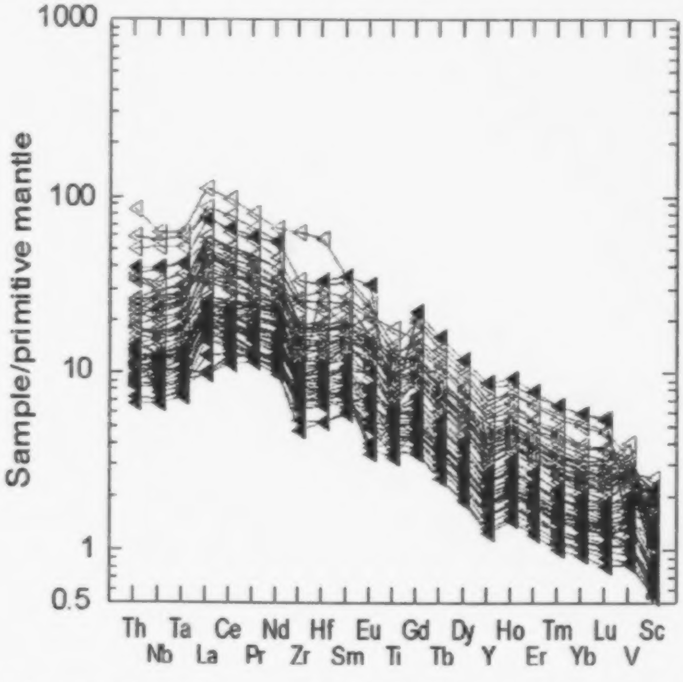


Figure 6. Mantle-normalized extended element diagrams of the olivine gabbro, melagabbro and peridotite of the Hele intrusion (normalizing factors *from* Sun and McDonough 1989). *See* Figure 5 for symbol legend.

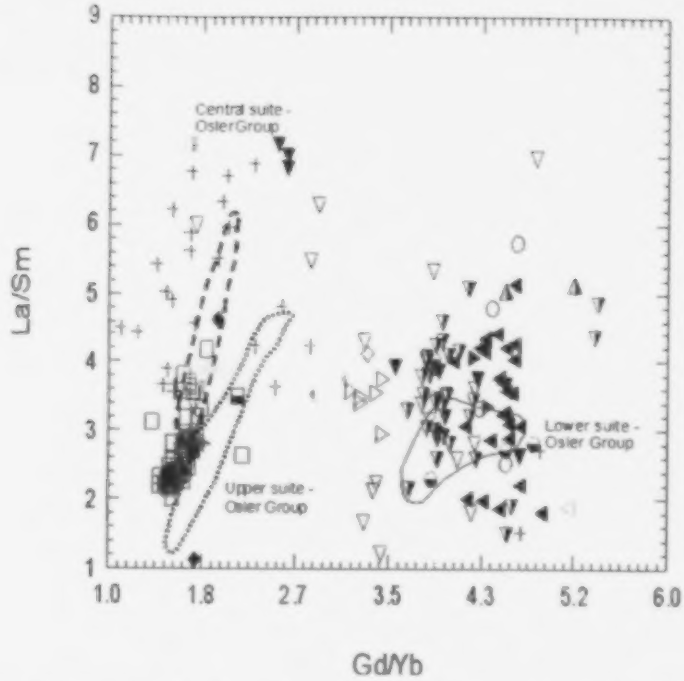


Figure 7. Gd/Yb versus La/Sm diagram of the mafic to ultramafic intrusive rocks and the Nipigon diabase sill complex with fields for the volcanic rocks of the Osler Group (*after* Lightfoot, Sutcliffe and Doherty 1991). *See* Figure 5 for symbol legend.

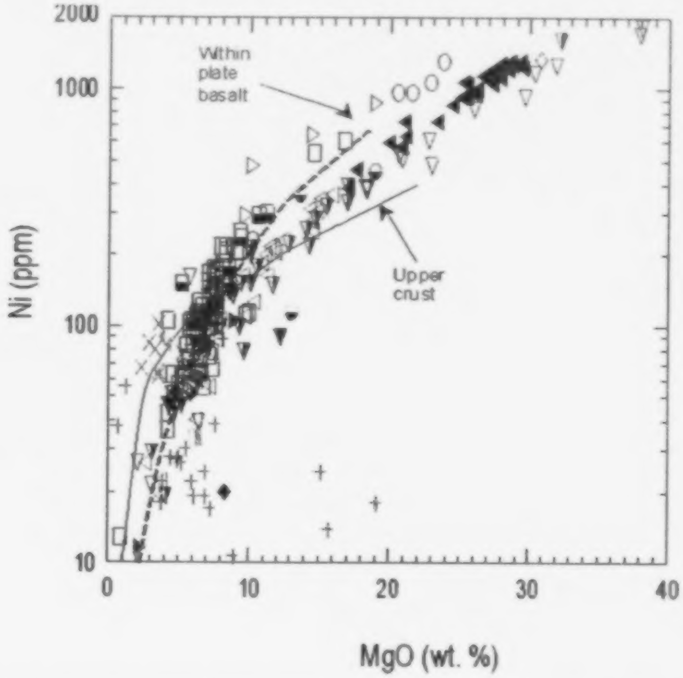


Figure 8. MgO versus nickel diagram of the mafic to ultramafic intrusive rocks and the Nipigon sill complex (*after* Lightfoot, Keays and Doherty 2001). *See* Figure 5 for symbol legend.

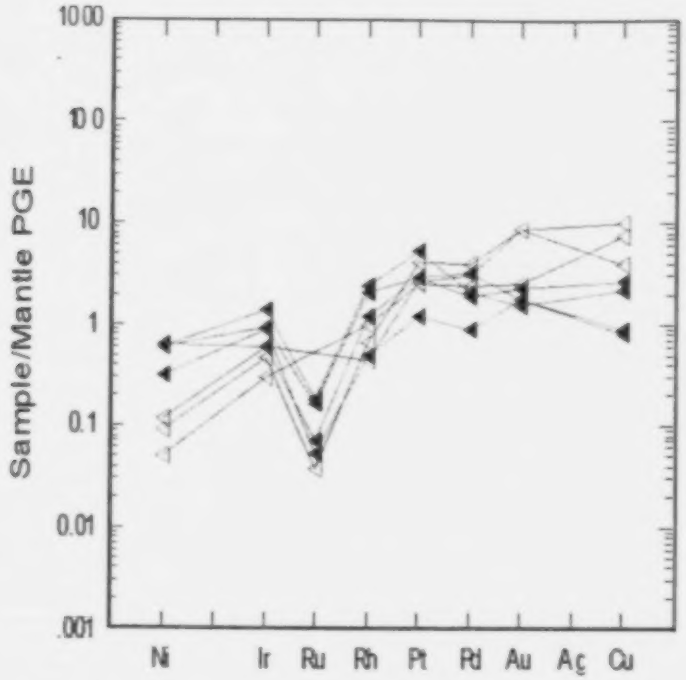


Figure 9. Primitive mantle-normalized platinum group element diagrams of the olivine gabbro, melagabbro and peridotite of the Hele intrusion (normalizing factors *from* Barnes et al. 1987). *See* Figure 5 for symbol legend.

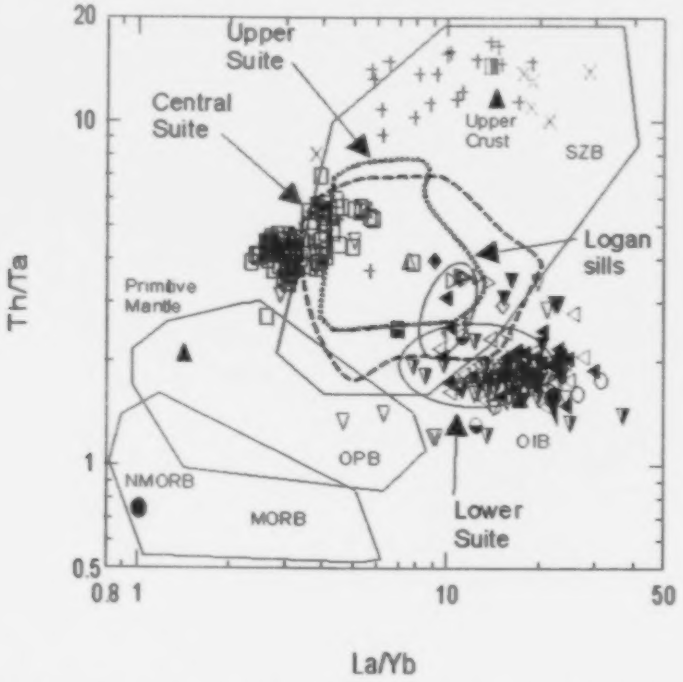


Figure 10. La/Yb versus Th/Ta diagram of the mafic to ultramafic intrusive rocks and the Nipigon diabase sill complex with fields for the volcanic rocks of the Osler Group and the Logan diabase sills south of Thunder Bay (*after* Condie, Frey and Kerrich 2002). *See* Figure 5 for symbol legend.

Seagull Intrusion

The Seagull intrusion is geochemically similar to the Hele intrusion and may also be subdivided into olivine gabbro, olivine melagabbro and peridotite. The peridotites have high MgO contents, up to 38.04 weight %, and follow a trend indicating that fractionation was controlled by olivine and clinopyroxene (*see* Figure 5). The olivine melagabbro have MgO contents of between 11 and 17 weight %, and follow a fractionation trend indicating a change from control by olivine and clinopyroxene crystallization to a control by plagioclase and clinopyroxene. The olivine gabbro have MgO contents of less than 11 weight %, and follow a trend controlled by plagioclase and clinopyroxene fractionation (*see* Figure 5). Total REE and HFSE concentrations in the peridotites are generally lower than in the olivine gabbro or olivine melagabbro (Figure 11), and Heggie and Hollings (2004) noted that the peridotite exhibits a decrease in total REE and HFSE abundances, accompanied by an increasingly negative Eu anomaly, upward through the intrusion. Heggie and Hollings (2004) also identified 3 geochemical units: 1) a basal unit in contact with rocks of the Quetico Subprovince and characterized by LREE enrichment and HREE depletion with $[La/Sm]_n$ ratios 1.4 to 3.0 and $[Gd/Yb]_n$ ratios of 3.1 to 4.0; 2) a main unit with $[La/Sm]_n$ ratios of 0.9 to 1.9, a negative Eu anomaly, and increasing fractionation between Lu and V; 3) a sub-main unit with REE values between the basal and main units and fractionated HFSE.

All of the rocks have weak negative TiO_2 and Zr anomalies on the mantle-normalized extended element diagram (*see* Figure 11), and a flattening of the pattern between La and Th similar to the Disraeli intrusions (Hart and Magyarosi 2004a). All 3 units have $[La/Yb]_{mn}$ and Gd/Yb ratios that are distinctly higher than the diabase sills, plotting toward the high end of the field defined by the Lower Suite of the Osler Group volcanic rocks (*see* Figure 7). Peridotites of the Seagull intrusion have a wider range of La/Sm ratios that the peridotites of the Disraeli and Hele intrusions, which may be a result of their less evolved compositions as indicated by their higher MgO contents.

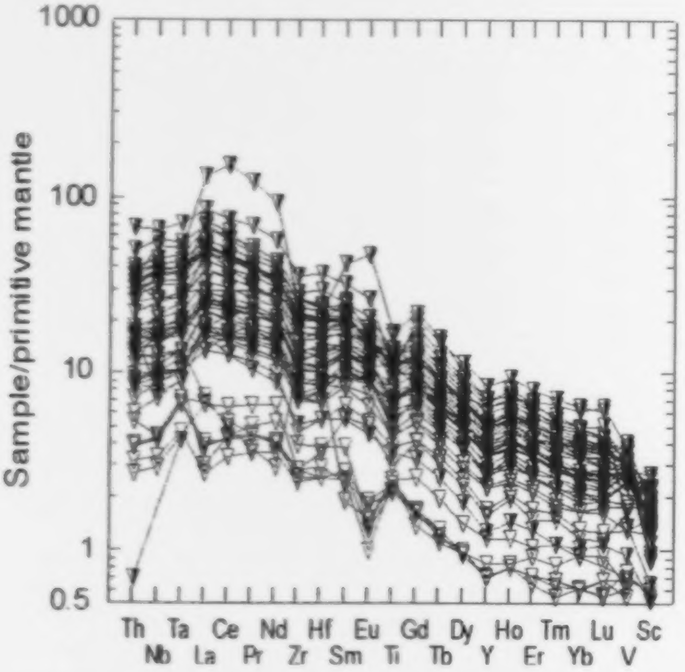


Figure 11. Mantle-normalized extended element diagrams of the olivine gabbro, melagabbro and peridotite of the Seagull intrusion (normalizing factors *from* Sun and McDonough 1989). *See* Figure 5 for symbol legend.

The peridotite and olivine gabbro are not enriched in nickel, and the peridotites follow an olivine-controlled igneous fractionation trend (*see* Figure 8). The olivine gabbro and peridotite have similar Pt/Pd ratios of 1.62 to 48.3, with the highest values being 3399.79 ppb Pt, 1198.07 ppb Pd, 13 ppb Au, 99.2 ppb Rh, 77.9 ppb Ru, and 524 ppb Te in a peridotite from drill hole WM00-09 of the Lower Zone currently being explored by Platinum Group Metals Ltd. (Platinum Group Metals Limited 2005). The rocks show a variety of slopes on a primitive mantle-normalized PGE diagram (Figure 12) with enrichment in the total PGE contents for mineralized samples and flat slopes for the nonmineralized samples, with variable negative Ru anomalies. Base metal contents of the peridotite and olivine gabbro overlap with values of 18 to 2270 ppm Ni, 10 to 913 ppm Cu, and 23 to 380 ppm Zn.

The Seagull intrusion also contains a monzogabbro, or granophyre, and portions of the olivine gabbro located near the margins of the intrusion contain minor amounts of pink feldspar. As in the Hele intrusion, the presence of pink feldspar usually correlates with higher K_2O contents, with values up to 4.66 weight %, and with no appreciable change in the Fe_2O_3 contents compared to the other olivine gabbro. Similarly, the high K_2O values are considered to be a result of assimilation of Sibley Group rocks and that the pink colour is a result of potassic alteration rather than hematization. The peridotite and olivine gabbro have REE and HFSE ratios that are comparable to ocean island basalts, as proposed by Heggie and Hollings (2004), and most of the rocks from the Disraeli and Hele intrusions, in contrast to the diabase sills (*see* Figure 10).

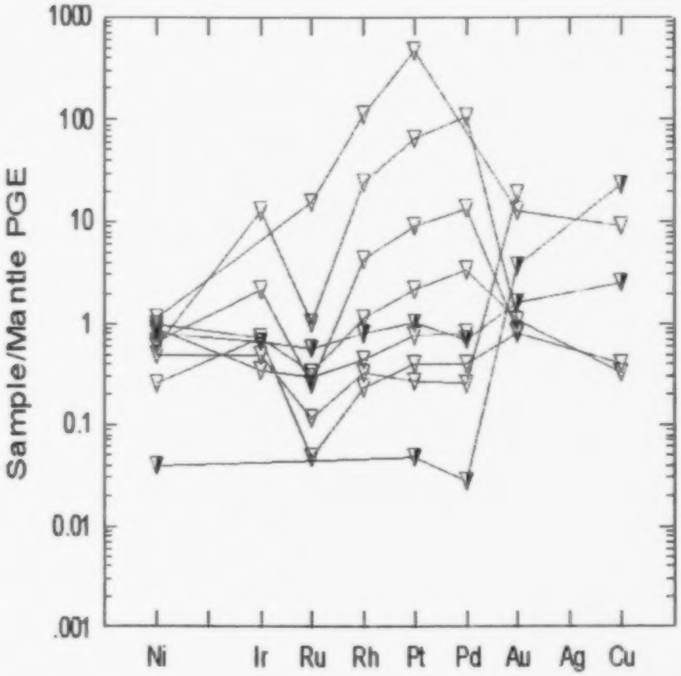


Figure 12. Primitive mantle-normalized platinum group element diagrams of the olivine gabbro, melagabbro and peridotite of the Seagull intrusion (normalizing factors *from* Barnes et al. 1987). *See* Figure 5 for symbol legend.

Disraeli Intrusion

A total of 4 peridotite samples and 4 olivine gabbro samples were analyzed for PGE by the nickel fire assay–ICP–MS method. The olivine gabbro and peridotites have similar Pt/Pd ratios of 0.95 to 6.0, with the highest values being 20.07 ppb Pt, 10.90 ppb Pd, 2.42 ppb Au, 2.40 ppb Ir, 0.71 ppb Rh, 4.45 ppb Ru, 162.2 ppb Se and 4.0 ppb Te in a peridotite. The samples have a flat positive slope in a primitive mantle-normalized PGE diagram with enrichment in Ir and Pt (Figure 13) compared to the trends for the diabase sills that follow a trend similar to that of most continental flood basalts (Hart, terMeer and Jolette 2002). The peridotite and gabbro are not enriched in nickel, and the peridotites follow an olivine-controlled igneous fractionation trend, which would be consistent with a parental MgO concentration of approximately 13 weight % (Hart and Magyarosi 2004a). Base metal contents of the peridotite and olivine gabbro overlap with values of 74 to 1320 ppm Ni, 17 to 204 ppm Cu, and 40 to 431 ppm Zn, although the peridotite generally have slightly higher values than the gabbro.

NIPIGON DIABASE SILL COMPLEX

The diabase sills plot along a line indicative of fractionation controlled mainly by plagioclase and clinopyroxene, as suggested by Sutcliffe (1987) (*see* Figure 9). Hart and Magyarosi (2004a) noted that although the CaO and MgO contents of the diabase are distinctively different from the peridotites, a trend subparallel to the olivine gabbro accounts for some of the similarities in appearance in the field. The diabase display a range in REE and HFSE concentrations that will require further investigation (Figure 14), but the $[La/Yb]_{mn}$ are distinct from those of the rocks of the mafic to ultramafic intrusions. Most of the diabase samples have weak negative TiO_2 anomalies, but no apparent Zr anomalies, on the

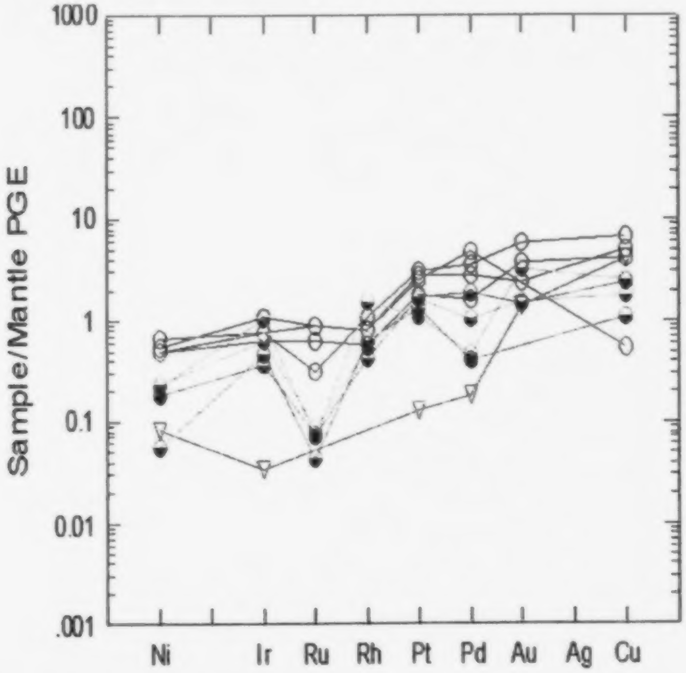


Figure 13. Primitive mantle-normalized platinum group element diagrams of the olivine gabbro, melagabbro and peridotite of the Disraeli intrusion (normalizing factors *from* Barnes et al. 1987). *See* Figure 5 for symbol legend.

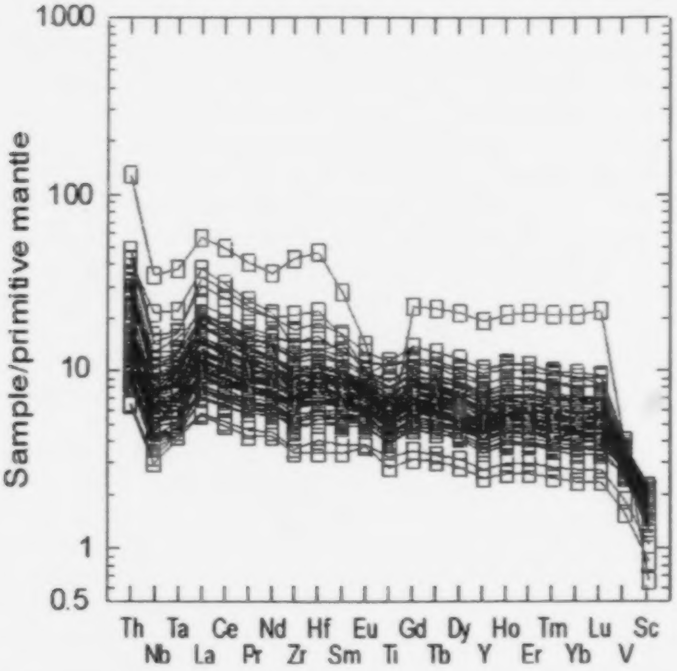


Figure 14. Mantle-normalized extended element diagrams of the Nipigon diabase sill complex (normalizing factors *from* Sun and McDonough 1989). *See* Figure 5 for symbol legend.

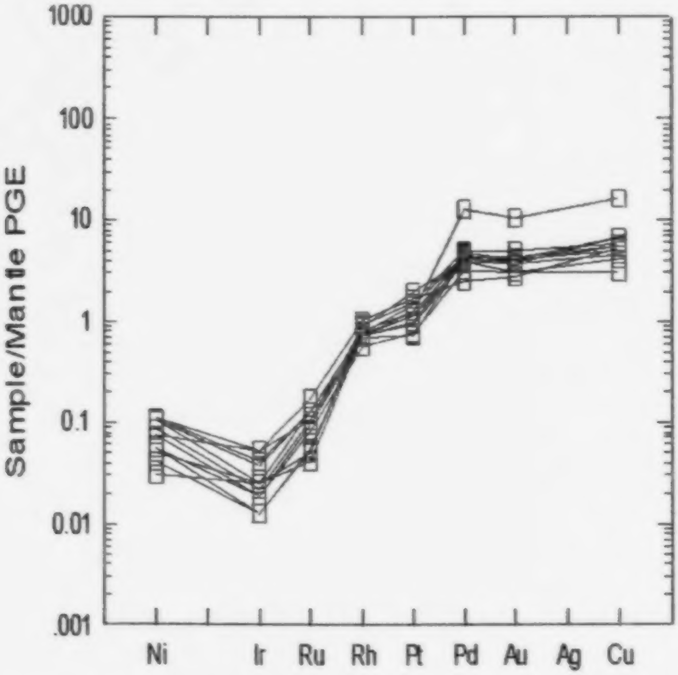


Figure 15. Primitive mantle-normalized platinum group element diagrams of Nipigon diabase sill complex (normalizing factors *from* Barnes et al. 1987). *See* Figure 5 for symbol legend.

mantle-normalized extended element diagram (*see* Figure 14), and pronounced negative Nb-Ta anomalies. Some HFSE and REE ratios for the diabase show some similarities to the Central and Upper Suite volcanic rocks of the Osler Group as has been suggested by Sutcliffe (1987)(*see* Figure 7).

The Nipigon diabase sills have lower TiO_2, Zr/Y and La/Yb values than the Logan diabase sills located to the south of Thunder Bay (*see* Figure 10) and have a regional distribution that extends south to at least the north side of the City of Thunder Bay (Hart 2003). Several samples collected from the area south of Thunder Bay have geochemical characteristics comparable to the Nipigon diabase sills (*see* Figure 10), but further investigation is required. This regional geographic distribution of high and low TiO_2 rocks is similar to regional distributions observed in some flood basalt provinces suggesting that the Logan and Nipigon sills may be part of a single intrusive event.

The presence of variants of the sills that have specific geochemical and/or geographic distribution has resulted in the introduction of a variety of new, informal names for the diabase sills in the past few years, such as the distinction between the Logan sills in the Thunder Bay area and the Nipigon sills around Lake Nipigon. In addition, new sill types, such as the Inspiration sills have also been identified (e.g., MacDonald 2004; Richardson and Hollings 2005). This does cause a problem, however, in that the historical term Logan sills has been used exclusively in the paleomagnetic literature, and in much of the international literature, for all of the diabase sills north of Lake Superior. Until these terminology issues are resolved, it is recommended that the historical nomenclature of Logan sills should be applied to all the diabase sills in the area north of Lake Superior, with subdivision into the informal terms of Logan sills in the south and Nipigon sills to the north. The Nipigon sills may be further subdivided into several chemical variants, such as the normal Nipigon, Inspiration, and Jackfish-like sills. Clarification of this nomenclature is contingent on further geochemical, petrological and geochronological work.

The Nipigon diabase sills are not enriched in nickel, and follow an igneous fractionation trend (*see* Figure 8). Platinum group elements in the diabase are similar to the trend followed by most continental flood basalts, and are comparable to the PGE contents and trends noted for the diabase sills from the Beardmore area by Hart, terMeer and Jolette (2002)(Figure 15). The diabase samples have Pt/Pd ratios of 0.9 to 2.32 with the highest values being 21.61 ppb Pt, 49.6 ppb Pd, 10.73 ppb Au, 0.24 ppb Ir, 0.94 ppb Rh, 0.88 ppb Ru, 524 ppb Se and 35 ppb Te. Base metal contents in the diabase samples range from 12 to 608 ppm Ni, 70 to 515 ppm Cu, and 14 to 410 ppm Zn.

Mapping and geochemical sampling by Sutcliffe (1986) and Hart, terMeer and Jolette (2002) suggested that the sills do not represent single cooling units. However, the results of detailed sampling of a number of continuous sill sections from diamond-drill cores suggest that some sills may be single cooling units, whereas others have chemical variations suggesting multiple pulses of magma that did not re-equilibrate before cooling (A.J. Richardson, Lakehead University, personal communication, 2005). However, the variations are subtle and generally not distinctive enough to be evident in a group of outcrop samples. The diabase sills have HFSE and REE ratios with some similarities to subduction zone basalts and the Central and Upper Suites of the Osler Group (*see* Figure 10).

SIBLEY GROUP

A total of 26 samples of a variety of rock types from the Sibley Group were analyzed for major, trace and rare earth elements so that the data could be used to investigate the effects of assimilation in the mafic to ultramafic intrusions and the diabase sills. Preliminary examination of the data indicates that most samples have similar REE and HFSE contents (*see* Figure 7). The samples have similar patterns on an extended element diagram normalized against the North American shale composite (Figure 16), with pronounced positive Y and Ba anomalies. Further investigation of the significance of these elemental contents and the effects of assimilation of these rocks on the composition of the various igneous rocks types is required.

Geophysics

An airborne magnetometer and gamma-ray spectrometer survey of 49 693 line-kilometres was flown over an area along the west side of Lake Nipigon extending from Dorion to just south of Armstrong during the summer of 2003 (Ontario Geological Survey 2004a). This survey was flown 100 m above ground level, using a 150 m flight line separation and covered the entire map area. Magnetic susceptibility measurements were recorded for each rock type at nearly every station during the mapping project, and specific gravity measurements were made for all samples analyzed for whole rock geochemistry (*see also* Hart 2005: MRD 147).

A ground gravity survey carried out along the western and southern margins of Lake Nipigon was published in 2004 (Ontario Geological Survey 2004b). This digital publication contains a detailed report describing the survey parameters, logistics and processing. A total of 4091 data points were acquired, and were augmented by 264 values donated by Bitterroot Resources Ltd. Station spacing varied from 250 m along detailed traverse lines, to approximately 1 km in the area south of Lake Nipigon, and to approximately 3 km in the northwestern part of the survey area.

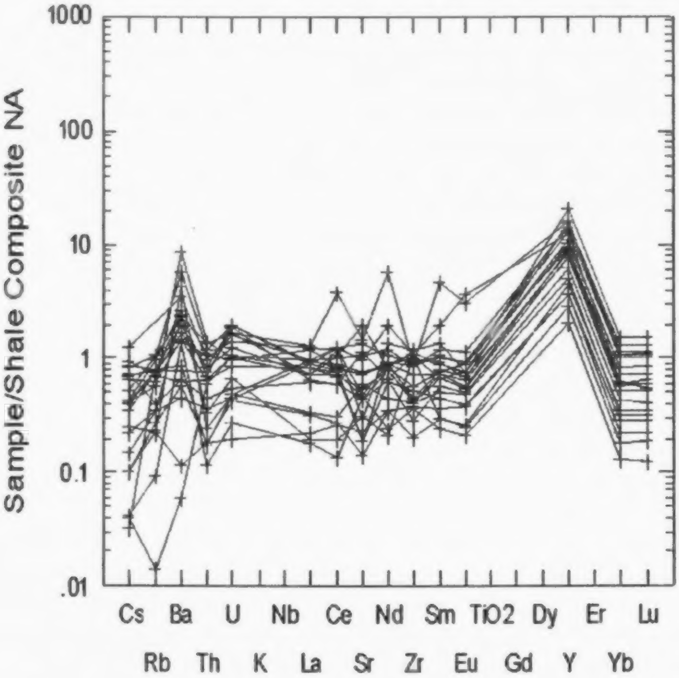


Figure 16. North American Shale Composite-normalized extended element diagrams of the Sibley Group sedimentary rocks (normalizing factors *from* Barnes et al. 1987). *See* Figure 5 for symbol legend.

The results of the aeromagnetic and gamma-ray spectrometer survey have been used to assist in the interpretation of the geology, particularly in areas with little outcrop. The total field magnetic and calculated first vertical derivative magnetic products are useful in delineating the magnetite-bearing diabase sills and the Archean iron formations (Ontario Geological Survey 2004a). The sill edges produce strong anomalies that were probably controlled by regional faulting. The gamma-ray spectrometer survey potassium and thorium responses were useful in delineating the Archean felsic intrusion rocks exposed to the east of the Black Sturgeon River.

INVERSION MODELLING

Inversion modelling of the airborne magnetic and the ground gravity data was performed on selected areas in order to develop a better understanding of certain geophysical signatures and areas of particular geological interest. The magnetic and gravity modelling were completed independently using the University of British Columbia (UBC) inversion software run in an unconstrained mode. Unconstrained models do not have a starting geological model and so are free to fit the geophysical data. The higher resolution of the magnetic surveys and smaller cell size tended to result in the definition of smaller and more complex features than the gravity models, which relied on sparser data and, as a result, yielded larger and smoother features.

Bodies exhibiting magnetic remanence could not be satisfactorily modelled because the modelling algorithm assumes that all responses are caused solely by normal magnetization. As the diabase sills in the area show a considerable amount of remanent magnetic character, this mitigated against developing good models of these bodies. Regardless of the magnetic polarity of the overlying sills, both the gravity and magnetic models were inclined to describe features that lie below the sill, but not the sill itself. This is despite the fact that the diabase sills give rise to moderately high magnetic susceptibility and density contrasts. The reason for this is probably due to the small model windows used (which were necessary for reasonable computation times) relative to the large area covered by the sills. As the geophysical footprints of the flat-lying and relatively uniform sills are much larger than the model windows, the parts of the responses contained within the model areas were insufficient for them to be modelled. Contrasting physical properties in the steeply dipping rocks below the sills could be observed in both the magnetic and gravity data and, therefore, could be modelled effectively.

The magnetic and gravity models produced 2 different possible outlines for the Seagull and Hele intrusions. The magnetic models resembled the known outlines of the Seagull and Hele intrusions, with the Seagull intrusion represented as a sill with a deeper, keel-like, east-trending anomaly, whereas the Hele intrusion was displayed as a relatively thin, shallow sill. The gravity anomalies associated with these intrusions are offset from the magnetic anomalies and are located at a greater depth. At the Seagull intrusion, the anomaly is located to the west of the peridotite outcropping, below the area between Seagull and Moraine lakes (*see* Figure 2; *see* Preliminary Map P.3562). This anomaly underlies the lateral extension of the intrusion to the east, but must be associated with a body located at depth. The anomaly associated with the Hele intrusion is located along the western edge of the surface expression of the intrusion and extends to the southwest toward Stewart Lake (*see* Figure 2). The Hele anomaly extends under the peridotite outcropping in northern Stirling Township. Both of these anomalies may represent extensions of these ultramafic intrusions, and may represent the feeder zones, as feeder zones have not been located for either of the intrusions. However, these anomalies may also represent high density rocks located in the Quetico Subprovince which underlies the map area.

Structural Geology

The Archean Quetico Subprovince metasedimentary rocks in the northeast portion of the map area have a schistosity oriented at approximately 050 to 060°, with near vertical dips, which is usually oblique to the bedding plane. In the southern portion of the map area, the airborne magnetic survey indicates a regional fabric with about an 080° orientation in the migmatitic rocks (Ontario Geological Survey 2004a). This fabric may be a result of the large-scale interbanding of the amphibolite and felsic intrusive rocks. In a few locations with more competent lithologies, such as quartz veins or leucocratic tonalite dikelets, there appears to have been isoclinal folding of some beds. The more competent lithologies also provide evidence of extension along the schistosity, possibly related to the folding event (*see* Photo 3). The felsic intrusive dikes and dikelets that intruded the Quetico Subprovince rocks generally follow the trend of the schistosity in the northern portion of the map area. Toward the south, the felsic intrusive rocks and amphibolites resemble migmatites in some locations, whereas, in other locations, the felsic rocks appear to have intruded the amphibolites (*see* Photo 2). The larger muscovite and biotite granite bodies appear to have more irregular contact orientations, but may be controlled by the regional fabric on a larger scale.

The Sibley Group sedimentary rocks are relatively flat lying, with dips of less than 5° and strikes that are usually difficult to determine. The sedimentary rocks unconformably overlie the Archean rocks of the Quetico Subprovince, and Cheadle (1986) estimated up to 200 m of topographic relief on the Archean paleosurface at the time of deposition of the Sibley Group. This variation in the paleosurface is most noticeable in the area around Wolf Lake where the basal units are part of the Rossport Formation rather than Pass Lake Formation. This variation in the paleosurface probably controlled sedimentation processes on a local scale, such that, although the bedding is generally flat lying, the orientation on an outcrop scale may be highly varied complicating stratigraphic correlations (P. Fralick and B. Rogala, Lakehead University, personal communication, 2003). Regionally, the Sibley Group thickens to the south under Lake Superior and 2 additional formations overlie the Kama Hill Formation (Rogala 2003), and thins to the north and west (e.g., Cheadle 1986).

Proterozoic peridotite intrusions intrude the Archean rocks of the Quetico Subprovince and Proterozoic sedimentary rocks of the Sibley Group. The Seagull intrusion appears to be lopolithic intruding along or close to the contact between the Quetico Subprovince and the Sibley Group. The central portion of the intrusion appears to be saucer shaped, but this may be a product of post-intrusion faulting, and a flat-lying sill along the periphery of the body. An underlying, or peripheral, feeder structure for the Seagull intrusion has not yet been identified. The Hele intrusion appears to be a relatively flat-lying sill with no known feeder zone, although there are fewer drill holes with which to constrain the geometry. The Hele intrusion appears to have intruded into the Sibley Group sedimentary rocks, which may be an explanation for the greater volume of monzogabbro in the intrusion.

The Nipigon diabase sills are generally shallowly dipping on a regional scale, locally dipping up to 30° along prominent ridges such as east of Anders Lake (*see* Preliminary Map P.3562). Shallow dips to the diabase are most apparent in areas of greater exposure, such as the area burned by the 1999 forest fire in the Mound Lake area (*see* Figure 2). In the area immediately north of the natural gas pipeline, a diabase sill can be observed to dip shallowly to the north, whereas, along the Black Sturgeon River, the same sill can be observed to dip shallowly east (Photo 24). The shallow inward-dipping orientation of this sill, forming a broad saucer with a width of about 5 km, is also visible in the airborne magnetic pattern (Ontario Geological Survey 2004a). A number of these saucer-shaped sills, with widths of up to 6 km and interiors occupied by older rock types, are evident from the airborne magnetic survey with one of the better examples observed in the area between Wolfpup Lake and Eagle Mountain (*see* Preliminary Map P.3562). Variation in sill orientation over short distances is common in other mafic sill complexes (e.g., Tasmania: Leaman 1975; Karoo: Chevallier and Woodford 1999). This change in orientation may be due to a number of factors including a change in orientation of the principal stress direction (Gretener 1969) during sill emplacement, and the sill may follow pre-existing structures such as faults. These processes may be particularly significant, as the sills apparently intruded the Archean rocks of the Quetico Subprovince as commonly as they do the sedimentary rocks of the Proterozoic Sibley Group. There appear to be at least 3 major sills, and possibly a number of thinner (5 to 25 m) sills in the area, but correlation between outcrops and diamond-drill holes is complicated by the saucer shape of some sills, the presence of block faulting that may postdate sill emplacement, and the lack of a geochemical difference between the sills (*see* Preliminary Map P.3563, back pocket).

Jointing in the diabase sills may be either arcuate or linear. The arcuate joints formed by cooling of the magma vary in strike direction by up to 70° and are commonly observed on horizontal surfaces. Jointing was not as well exposed in this map area as in the area to the north (Hart and Préfontaine 2004a, 2004b), where close to the sill contacts crude polygon joint patterns with "T" or flattened "Y" junctions are observed. However, the "Y" junctions that should replace the "T" and flattened "Y" junctions in a classic polygonal jointed unit are absent (e.g., Aydin and DeGraff 1988) and the lack of "Y" junctions suggests a slow cooling rate which would be in agreement with the 315 to 560 year cooling times for the sills estimated by Sutcliffe (1986). Linear joints are commonly north trending and transect the cooling fractures suggesting that they are associated with late, possibly regional, structures. The combination of these 2 joint sets probably represent the large-scale jointing, which is commonly observed in the cliff exposures of the major sills.

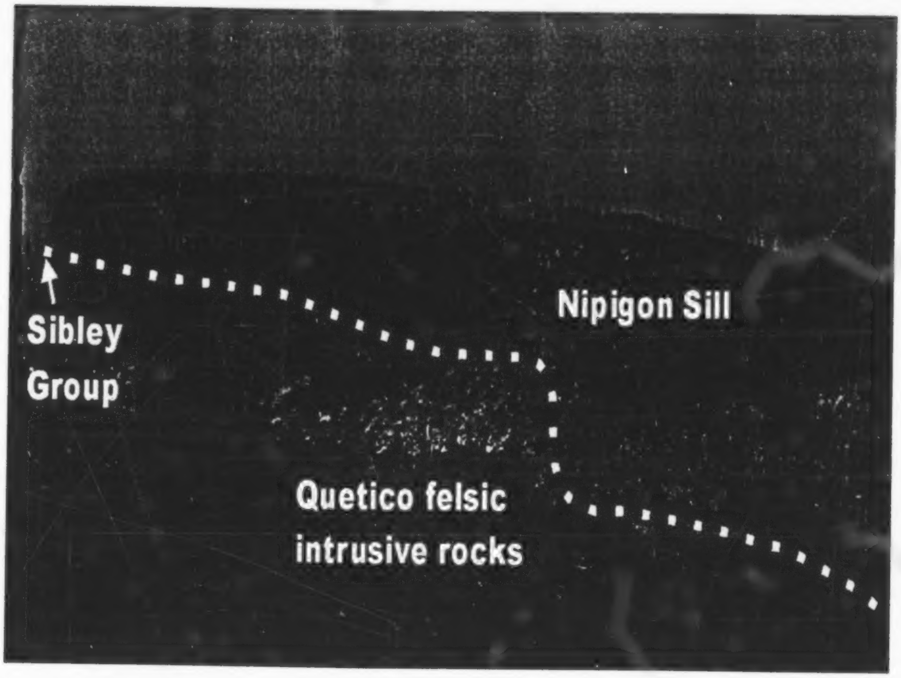


Photo 24. Approximate trace of the north- to northeast-dipping contact between the overlying Nipigon diabase sill and felsic intrusive rocks of the Quetico Subprovince, with a thin interval of Sibley Group sedimentary rocks located between these two units on the southwest side of the cliff. Photograph looking west in the area immediately north of the natural gas pipeline. Width represented in the photograph is approximately 1.25 km

FAULTS

There are 2 major regional fault trends that define the structural zone referred to as the Black Sturgeon fault zone, and a third trend that may only represent minor late movement along pre-existing Archean structures (Figure 17). A series of subparallel, north-trending faults may be traced into the adjacent map areas of the Nipigon Embayment to the north. A series of northwest-trending faults may be traced to the west into the adjacent Wabigoon Subprovince. The combination of these 2 fault trends has been interpreted to be *en échelon* resulting in the formation of an asymmetric basin or graben as originally proposed by Coates (1972). Both of these fault directions are evident in the topography and exposure of Nipigon diabase sills in the map area. A number of northeast-trending faults parallel the fabric of the Quetico Subprovince. Accurate determination of displacements on these structures has not been possible, as they are generally obscured by talus slopes and glacial deposits.

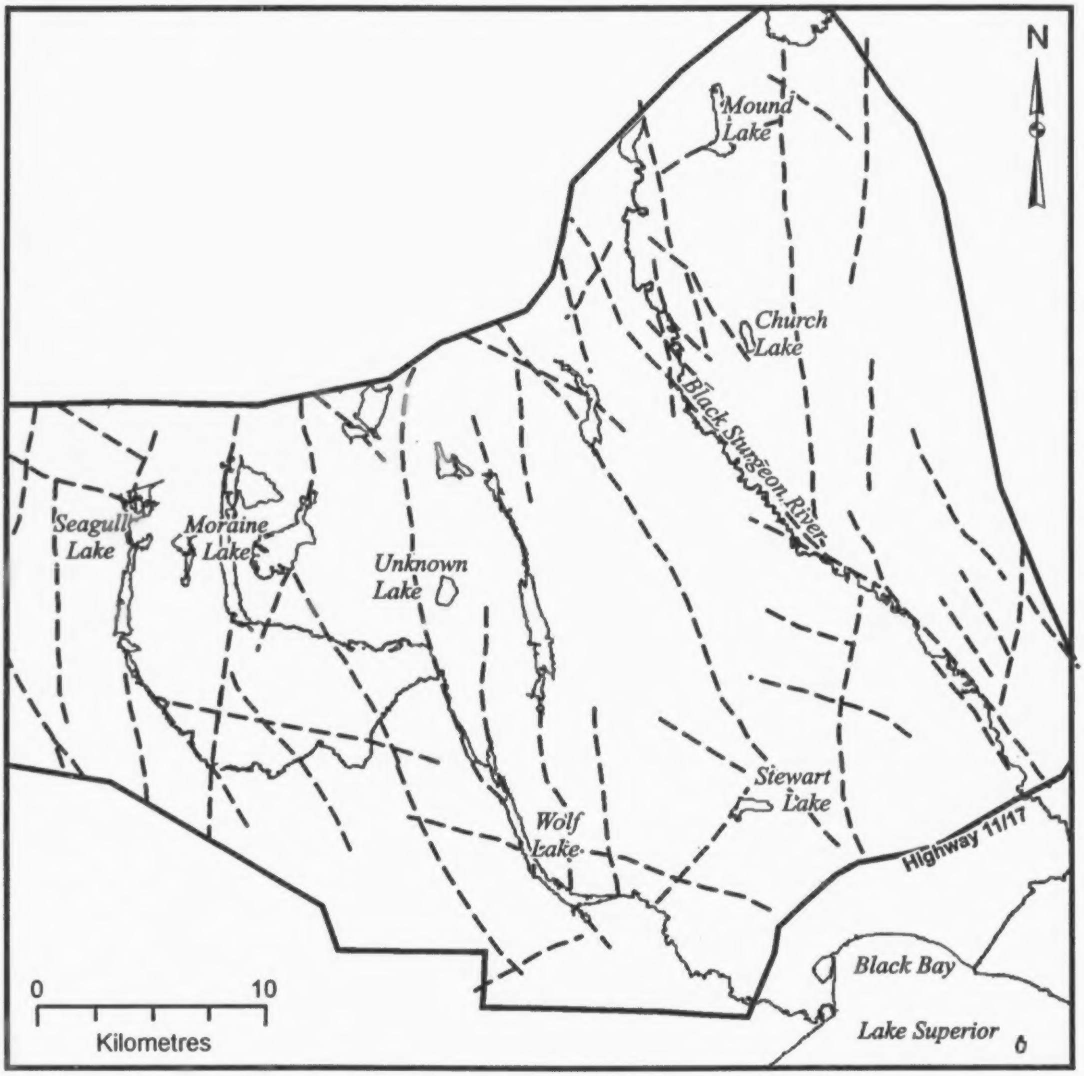

N
Mound Lake
Church Lake
Black Sturgeon River
Seagull Lake
Moraine Lake
Unknown Lake
Stewart Lake
Wolf Lake
Highway 11/17
Black Bay
Lake Superior
0
10
Kilometres

Figure 17. Distribution of major faults and regional structures in the southern Black Sturgeon River and Seagull Lake map area.

A series of subparallel north-trending faults are interpreted to be regionally continuous structures that can be traced for over 50 km north into the area of the English Bay Complex. These faults may also correlate with north-trending structures in the northern Gull Bay area of the northern Lake Nipigon Region Geoscience Initiative bedrock map area (MacDonald 2004), as has been previously proposed by several authors (e.g., Middleton 2001). Vertical displacements on these faults are variable and, in some areas, such as along the Black Sturgeon River, the faults appear to have vertical displacements of up to 350 m (*see* Preliminary Map P.3563, back pocket). There appears to have been little lateral displacement on these faults based on the correlation of the iron formations across Black Sturgeon Lake (Hart and Magyarosi 2004a). North-trending faults appear to cut, and may have controlled, the emplacement of the Seagull peridotite intrusion and, possibly, the Hele peridotite intrusion. Apparent flexures in the north-trending faults are thought to be a result of separate northwest-trending structures.

A series of northwest-trending faults are interpreted to displace the north-trending faults and are also regionally continuous structures that can be traced for 50 km into the adjacent central Wabigoon Subprovince. There is no apparent lateral displacement along these faults, but also, there is no unique marker horizon that can be used to determine if any offset has occurred. Vertical displacements appear to be varied and, in some locations, such as in southeast Hele Township, a northwest-trending fault is the locus of major uplift of the area to the east of the Black Sturgeon River (Photo 25). These faults define the shape of the ultramafic intrusions and may have had some control on their emplacement.

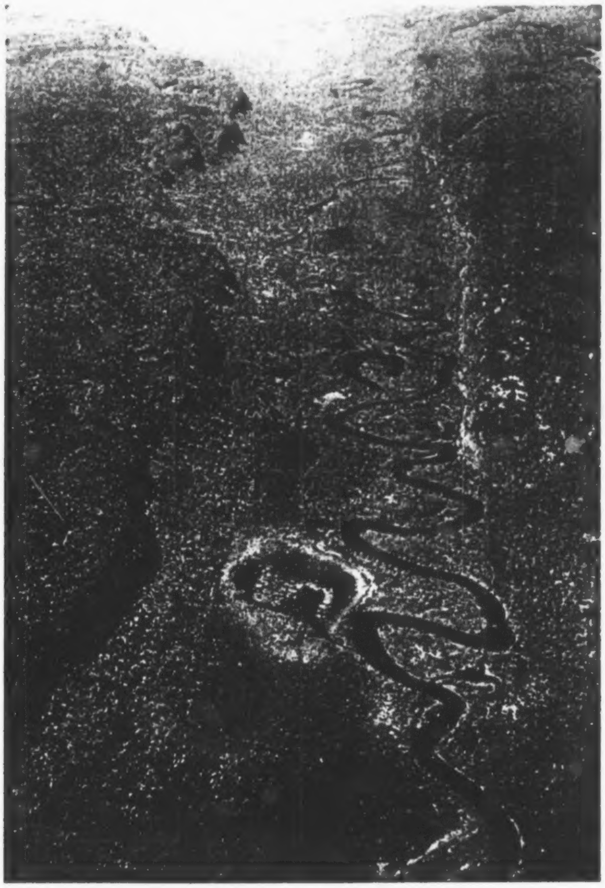


Photo 25. A northwest-trending fault defining the erosional valley of the Black Sturgeon River, with the Archean to the right (east) and Hele intrusion to the left (west). Photo looking northwest and the valley is approximately 800 m wide. Photo courtesy of J. Scott.

The northeast-trending faults are less well defined and appear to parallel the fabric of the Quetico Subprovince rocks. These faults appear to have some control over the distribution of the diabase sills, but it is not clear whether there has been any major displacement along the structures. It is difficult tracing these faults into the central portion of the map area.

The timing of the different faults is not known, and it is probable that they have been reactivated. There have been several proposals made to account for the structural history of the area, with most focussing on the Sibley Group sedimentary rocks. Coates (1972) proposed a half graben with the Black Sturgeon River as the eastern boundary that also served as the main control on the deposition of the Sibley Group. Franklin et al. (1980) proposed that a failed arm of the Mesoproterozoic Keweenawan Midcontinent Rift created a basin, which included the half graben. Sutcliffe (1986) further developed the failed arm model as a major control on the emplacement of the peridotite intrusions and the diabase sills, and highlighted the existence of a subparallel fault system along the Nipigon River to the east. Alternatively, Fralick and Kissin (1995) proposed that the thermal upwelling that formed the English Bay Complex was followed by relaxation and formation of an intracratonic basin in which the Sibley Group was deposited.

The failed arm model predicts the presence of dike swarm (e.g., Ernst and Buchan 2003), in this case, north trending and centred on Lake Nipigon. The paleomagnetic and geochemical study of the north-trending dikes located to the west of the Nipigon Embayment by Ernst et al. (2005) suggests that they are part of the Marathon dike swarm (2101–2121 Ma), not the Keeweenawan. If the identification of these dikes as part of the Marathon swarm is indeed correct, then, combined with the lack of a north-trending dike swarm north or east of the Nipigon Embayment, a key element of the failed arm model appears to be absent.

The presence of Pass Lake Formation rocks at the base of a number of diamond-drill holes in the map area suggests that the half graben was present before, or was formed during, the deposition of the Sibley Group, sometime between 1670 and 1339 million years ago (Heaman et al. 2005; Franklin 1978). The occurrence of Pass Lake Formation at the base of Moseau Mountain, on the east side of the Black Sturgeon River, suggests that fault activity continued throughout the entire period of sedimentation, or that there has been significant post-sedimentation fault re-activation. At this time, there is no definitive means of distinguishing between these 2 models as, in either case, the general scarcity of Sibley Group rocks in the area to the east could result from uplift and erosion. The location of Pass Lake Formation rocks at higher elevations to the east could mean that sedimentation originally extended across much of the Nipigon Embayment, consistent with the first model.

Timing and magnitude of displacement along faults related to the emplacement of either the ultramafic intrusions or diabase sills is also difficult to determine. The high degree of fracturing and hematite alteration in some of the diamond drill core from the Seagull intrusion (1106–1124 Ma: Heaman et al. 2005) suggests post-emplacement fault activity. Extensive hematite mineralization and the occurrence of uranium mineralization in north-trending structures has an age of 1090±20 Ma (Ruzicka and LeCheminant 1984). Current interpretations suggest that faulting has resulted in displacement of igneous horizons within the Seagull intrusion, but it is just as possible that the intrusion was emplaced into a pre-existing structure to produce its current form. Pre-existing fault structures probably, in part, controlled the emplacement of the Nipigon sills (1111–1113 Ma: Heaman et al. 2005), as has occurred in other mafic sill complexes (e.g., Leaman 1975). However, due to the lack of a distinctive marker in the area, it is difficult to determine if the apparent disjointed nature of many of the sills is the result of the sills ramping upward along pre-existing structures and subsequently being eroded away, or if it is a product of late post-emplacement fault displacement.

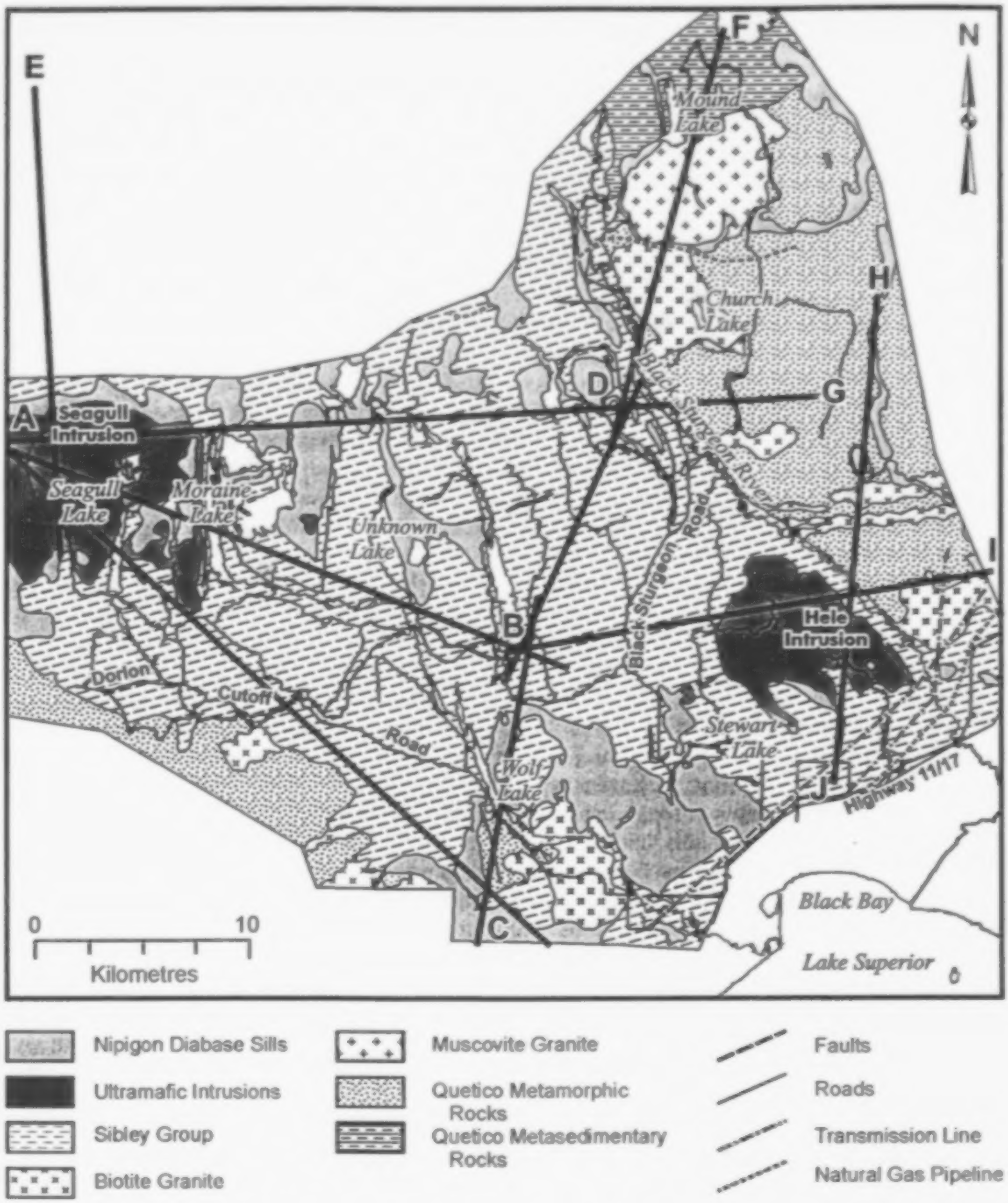
CROSS-SECTIONS

A number of cross-sections were constructed based on outcrop, diamond drill hole, and airborne geophysical information (Preliminary Map P.3563, back pocket). Diamond drill holes in the area serve as anchor points for at least one end of a section in order to provide some subsurface information (Figure 18). Detailed subsurface information is limited, as diamond-drill holes are separated by up to 15 km, and the Nipigon diabase sills have removed portions of the Sibley Group, thereby hindering stratigraphic correlation. Several assumptions were made in the construction of these sections, and include 1) the Sibley Group sedimentary rocks are flat lying, although there was probably significant localized variation as a result of depositional paleosurface topography; 2) faults have been oriented vertically, as there is not enough information available on their possible dips; 3) the depth to the Quetico Subprovince basement rocks decreases to the west, although it is not known whether this decrease is gradual or the result of a series of steps related to block faulting; and 4) the Nipigon diabase sills have been interpreted to ramp along some faults, which is a common feature in other mafic sill complexes, but are truncated against other faults, as the timing of fault activity is not well understood.

The 3 sections that cross the Black Sturgeon River suggest that there is approximately 350 m of displacement that is shown as a single fault scarp paralleling the Black Sturgeon River. This displacement is similar to estimates of 213 to 305 m by Coates (1972) and 420 m by Sutcliffe (1986). As discussed above (*see* "Structure"), the presence of Pass Lake Formation rocks at the base of Moseau Mountain, on the east side of the Black Sturgeon River, suggests that fault activity continued through the entire period of sedimentation or that there has been significant post-sedimentation re-activation. The lack of Pass Lake Formation rocks in the map area to the north of Moseau Mountain (Hart and Préfontaine 2004a, 2004b) may be a result of paleosurface variations, rather than faulting. West of the Black Sturgeon River, a series of north-trending and northwest-trending faults are interpreted uplift the Quetico Subprovince basement from approximately –100 m (below sea level) to about 340 m asl between the Black Sturgeon River and the west side of the Seagull intrusion. The presence of the block faults is interpretative; alternatively, a model of a shallowly east-dipping Sibley Group strata deposited on a shallowly dipping Quetico Subprovince basement, with little to no faulting is equally possible.

Emplacement of the ultramafic intrusions would appear to have occurred along pre-existing structures that were subsequently re-activated after emplacement of the younger diabase sills. Current information from diamond drilling suggests that faulting has displaced igneous horizons within the intrusion, with the most pronounced feature being the displacement of the contact with the basement. These same faults offset diabase sills that intruded, and are chilled against, the peridotite. Mapping also indicates that the both the Seagull and Hele intrusions were originally much more laterally extensive, with the Seagull intrusion extending for up to 16 km in an east to west direction. Based on the current diamond drill hole information, all that remains is a sill-like body; however, the cumulate textures in the peridotite suggest that it may have been once part of a much thicker body. Both the Seagull and Hele intrusions have associated gravity anomalies located at depth peripheral to the surface expression of the intrusions (*see* "Geophysics"). These gravity anomalies may represent extensions to, and/or possible feeder zones to the intrusions.

There is evidence that there may be 3 major diabase sills in the area, although this interpretation is dependant on the nature of the fault displacements in the areas without diamond drill hole control. The lack of a distinctive marker unit means that correlation of the sills on the scale of this map is not possible. The diabase sills are interpreted to have ramped upward along pre-existing structures and, in some areas, formed broad saucer-shaped bodies. The sills continue to the east beyond the Black Sturgeon River and intrude the rocks of the Quetico Subprovince. Sills may also intrude the Quetico Subprovince basement rocks to the west in the lower portion of the cross-sections and. although there is no information to support this interpretation, the fact that no drill holes penetrate for any distance into the basement does not preclude it. A feeder zone, or zones, for the Nipigon diabase sills has not been represented on the section as there is no evidence as to their location, whether there is one or multiple feeders or fissures, or which fault would be the most likely magma conduit. Post-emplacement faulting probably also has occurred, which would explain the apparent truncation of the sills in areas such as the Seagull intrusion.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Seagull Lake
Moraine Lake
Unknown Lake
Black Sturgeon River
Black Sturgeon Road
I
B
Hele Intrusion
Dorion
Cutoff
Road
Stewart Lake
Wolf Lake
J
Highway 11/17
C
Black Bay
Lake Superior
0
10
Kilometres
Nipigon Diabase Sills
Ultramafic Intrusions
Sibley Group
Biotite Granite
Muscovite Granite
Quetico Metamorphic Rocks
Quetico Metasedimentary Rocks
Faults
Roads
Transmission Line
Natural Gas Pipeline

Figure 18. Location of geological cross-sections shown in detail on Preliminary Map P.3563.

Economic Geology

PLATINUM GROUP ELEMENTS

Seagull Intrusion

Past work on the mineralization hosted by the Seagull intrusion was summarized by Hart and Magyarosi (2004a). Re-sampling of available drill core outlined 2 zones of mineralization that previous sampling had indicated to be only anomalous in PGE mineralization (East West Resource Corporation 2004a). The upper zone contains 1.52 ppm Pt, 1.78 ppm Pd, 0.34 ppm Os, 0.11 ppm Rh, 0.23 ppm Ir, 0.15 ppm Au, 0.58% Cu, and 0.34% Ni over 3 m (East West Resource Corporation 2004a, 2004b). The lower zone contains 1.56 ppm Pt, 1.87 ppm Pd, 0.20 ppm Os, 0.10 ppm Rh, 0.18 ppm Ir, 0.15 ppm Au, 0.55% Cu, and 0.35% Ni over 3 m (East West Resource Corporation 2004a, 2004b). An additional 7 diamond-drill holes were completed in 2004 by Platinum Group Metals Ltd. under an option agreement with East West Resource Corporation to investigate the continuity of this mineralization. As a consequence of this work, mineralization was intersected near the base of the intrusion consisting of 2.38 g/t Pt, 2.65 g/t Pd, 0.19 g/t Au, 0.18 g/t Rh, 0.39 g/t Os, 0.34 g/t Ir, 0.08 g/t Ru, 0.19% Cu and 0.20% Ni over 3.21 m in WM04-17 (Platinum Group Metals Ltd. 2005). This mineralization may be a previously unrecognized fourth zone, and future work by Platinum Group Metals Ltd.–East West Resource Corporation is planned to continue to further investigate this mineralization.

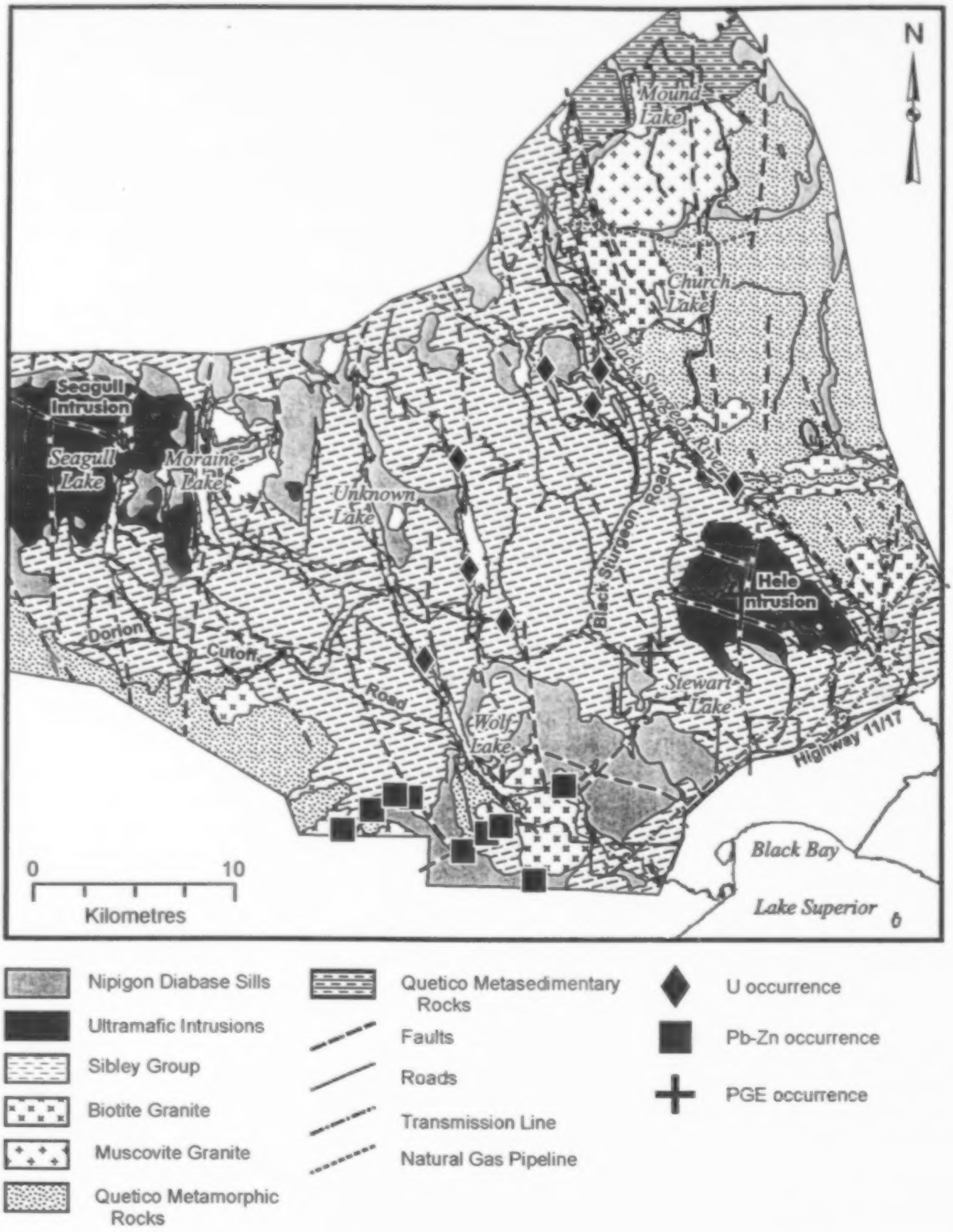
Mineralization in the basal zone is present near the lower contact of the intrusion, and is interpreted to be caused by sulphur saturation of the magma during initial stages of emplacement (Heggie and Hollings 2004). The upper and lower zones are associated with more primitive whole rock geochemistry and mineralogy possibly reflecting an influx of less evolved magma. The mineralogy has been characterized by Heggie and Hollings (2004) and the following details are from that source. Nickel and copper sulphide minerals occur as disseminated bravoite and chalcopyrite, respectively, found interstitial to olivine. Copper is also present as veinlets of native copper crosscutting sulphide minerals. Platinum group minerals are located at the grain boundaries of NiFe sulphide minerals, and are dominated by sperrylite, keithconnite, stibiopalladinite and a copper palladium alloy.

Hele Intrusion

Although lithologically and geochemically similar to the Seagull intrusion, mineralization has not been identified in the Hele intrusion. Two diamond-drill holes, totalling about 805 m, were completed in the central portion of the intrusion by Teck Cominco Ltd. in 2002. Additional details for these diamond-drill holes are contained in MRD 147 (Hart 2005). Significant sulphide mineralization was not observed during the current mapping program.

Other Properties

Past work for PGE mineralization is concentrated in the portion of the map area compiled from the mapping completed in 2003 and shown on Preliminary Map P.3539 (Hart and Préfontaine 2004b) and included in the accompanying report (OFR 6138: Hart and Magyarosi 2004a). The work completed is summarized in Table 2, and additional information regarding the diamond drill holes is contained in MRD 133 (Hart and Magyarosi 2004b).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Church Lake
Black Sturgeon River
Seagull Intrusion
Seagull Lake
Moraine Lake
Unknown Lake
Black Sturgeon Road
Hele Intrusion
Dorion Cutoff Road
Stewart Lake
Wolf Lake
Highway 11/17
Black Bay
Lake Superior
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Kilometres
Nipigon Diabase Sills
Ultramafic Intrusions
Sibley Group
Biotite Granite
Muscovite Granite
Quetico Metamorphic Rocks
Quetico Metasedimentary Rocks
Faults
Roads
Transmission Line
Natural Gas Pipeline
U occurrence
Pb-Zn occurrence
PGE occurrence

Figure 19. Mineral occurrences in the southern Black Sturgeon River and Seagull Lake map area.

Table 2. Past work for copper, nickel, and/or PGE mineralization; property number refers to Preliminary Map P.3562 (back pocket).

Property Number	Company	Year	Diamond Drill Hole Numbers	Past Work
5	Teck Cominco Ltd – East West Resource Corporation	2002	SR02-01	Airborne magnetic and electromagnetic surveys, horizontal loop electromagnetic survey
8	Bitterroot Resources Limited	2001	DDH-1, DDH-2, DDH-3, DDH-4, DDH-5, DDH-6	Ground magnetic survey and gravity survey
9	Teck Cominco Ltd – East West Resource Corporation	2002	ST02-01	Airborne magnetic and electromagnetic surveys, horizontal loop electromagnetic survey

Table 3. Past work for copper mineralization; property number refers to Preliminary Map P.3562 (back pocket).

Property Number	Company	Year	Diamond Drill Hole Numbers	Significant Results
6	Algoma Steel Corp. Ltd.	1967	DL-1-67, DL-2-67, DL-3-67	Trace chalcopyrite in diabase
7	Commerce Nickel Mines Ltd.	1965	Drilled but not in assessment files	Minor galena, native copper
10	Phelps Dodge Corp. of Canada Ltd.	1968	5 holes, but not in assessment files	
12	W. McAteer–W.P. Gilbert	1967	3 holes, but not in assessment files	
13	Noranda Exploration	1992	NI92-7, plus one unidentified	Not filed for assessment credit

COPPER

Trace, disseminated malachite was located along the bed of a stromatolitic limestone of the Middlebrun Bay Formation of the Rossport in the area west of Wolf Lake (*see* Figure 2). The limestone is overlain by a diabase sill and is weakly hornfelsed. This mineralization is similar to the copper mineralization explored in the area around Disraeli Lake to the north of the current map area. Past workers have suggested that the copper mineralization may be related to the intrusion of the diabase or ultramafic intrusions (e.g., Coates 1972). However, it is not clear if the metals are igneous or sedimentary in origin. The study of the effect of metamorphism in the Sibley Group by Rogala (2001) noted that one sill contact had a thin band of pyrite with chalcopyrite, magnetite, ilmenite, galena, and rare gold and silver. High gold content has been noted in a sample from McVicars Resources Muskrat Lake diamond drill hole ML01-3 at 239.8 m and also in samples from along the shore of Lake Nipigon (A.J. Richardson, Lakehead University, personal communication, 2004).

Past work for copper mineralization is concentrated in the portion of the map area compiled from the mapping completed in 2003 and shown on Preliminary Map P.3539 (Hart and Préfontaine 2004a) and included in the accompanying report (OFR 6138: Hart and Magyarosi 2004a). Mineralization consists of chalcocite hosted by the diabase sill or underlying Sibley Group sedimentary rocks (Coates 1972) with occurrences shown in Figure 19. The exploration results are presented by Coates (1972), and are summarized in Table 3, and additional information regarding the diamond-drill holes is contained in MRD 133 (Hart and Magyarosi 2004b).

LEAD AND ZINC

The Bishop occurrence is located in the same northeast-trending fault zone that hosts the Dorion Mine to the southwest. The fault zone cuts Archean granite and the overlying Proterozoic mudstone and siltstone, and contains a fault breccia with a carbonate and quartz matrix. Fragments in the breccia are subangular to subrounded and reflect the composition of the adjacent wall rock (Photo 26). Carbonate is a major component of the breccia matrix and is white, subhedral and coarse grained and appears to have crystallized in an open space. Quartz is clear to smoky occurring as euhedral crystals filling partially open spaces. Sphalerite is light yellow to greenish yellow occurring as 0.5 to 1.0 cm thick medium-grained bands close to the margins of the breccia zones. Exposure of the breccia is limited, but the

Table 4. Past work for lead-zinc(+silver) mineralization; property number refers to Preliminary Map P.3562 (back pocket).

Property Number	Company Name	Year	Diamond Drill Hole Numbers	Significant Results
26		1975		
27	Andowan Mines Ltd.	1969		
28	F.E. and J. Stephens	1980		
29	Noranda Exploration Co. Ltd.	1932	DO-82-7	30.5 m shaft in 1929
30	Noranda Exploration Co. Ltd.	1982	DO-82-1, DO-82-2, DO-82-3, DO-82-4, DO-82-5, DO-82-6, DO-82-8	3.53% Pb and 0.70% Zn over 1.9 m in channel sampling
31	W. Acker			
32	Santack Mines Ltd.	1972	1A, 2A, 3A, 4A, 5A, 6A, 7A, 8A	
33	J. Brayshaw			

sphalerite bands appear to be discontinuous. Galena occurs disseminated through the breccia carbonate matrix as euhedral, medium to coarse grains. The granite to the west of the shaft of the Bishop occurrence is, in part, a pegmatitic phase of the biotite granite suite with very coarse-grained ilmenite, and the ilmenite appears to be replacing magnetite.

Past work for lead-zinc mineralization is concentrated in the southern portion of the map area within the area underlain by rocks of the Quetico Subprovince. The mineralization is similar to that described for the Bishop occurrence, and is hosted by unconformity-related vein systems up to 1.2 m wide that cross the unconformity between the Sibley Group and Quetico Subprovince rocks (e.g., Shklanka 1969). Barite is a commonly reported accessory mineral in these veins and subhedral barite and quartz in an open-space fracture filling was observed in rocks of the Sibley Group located at the lamprey trap on the Wolf River, next to Highway 11/17. This was the only occurrence of barite in this form, and may be an indication of additional veins at depth. The unconformity-related lead-zinc-barite veins are reported to contain anomalous uranium values (e.g., Scott 1987). The exploration results are summarized in Table 4 with additional information regarding the diamond-drill holes contained in MRD 147 (Hart 2005).

Photo 26. Brecciated and altered siltstone in a carbonate and quartz matrix containing light yellowish brown sphalerite and dark grey galena, from the Bishop occurrence (station 87.1). The size of the pencil is approximately 15 cm in length.

URANIUM

The Tessier–Williamson, Hele Township, uranium occurrence is located in Hele Township along the east side of the Black Sturgeon River (*see* Figure 19). The occurrence is described by Scott (1987) as biotite-quartz-feldspar gneiss intruded by granitic pegmatites, and a grab sample returned 680 ppm U and 20 ppm Th. An attempt to locate the occurrence during the current field season was unsuccessful.

There are a number of properties in the map area that were explored for uranium between 1977 and 1980 (Table 5; *see* Figure 19), but no uranium mineralization was reported from this work. Of a total of 5 diamond-drill holes that were completed, only 2 holes drilled by Asarco Exploration Ltd. intersected the unconformity. Uranium mineralization located in the area to the north, east of Black Sturgeon Lake, is associated with hematite and specular hematite hosted by north-trending fractures in rocks of the Wabigoon Subprovince. The fractures are subparallel the trend of the Black Sturgeon deformation zone (Hart and Magyarosi 2004a). A U/Pb age of 1090±20 Ma for the uranium mineralization was reported by Ruzicka and LeCheminant (1984). The exploration results are summarized in Table 5 with additional information regarding the diamond-drill holes contained in MRD 147 (Hart 2005).

Table 5. Past work for uranium mineralization; property number refers to Preliminary Map P.3562 (back pocket).

Property Number	Company Name	Year	Diamond Drill Hole Numbers
16	Tessier–Williamson	1955	
19	Uranerz Exploration and Mining Corp.	1980	SO-1, SO-2, SO-3
20	Asarco Exploration Co.	1978	
21	Norcen Energy	1979	
22	Norcen Energy	1979	
23	Asarco Exploration Co	1979	WR-1, WR-2
24	Norcen Energy	1979	
25	Norcen Energy	1979	

RARE METALS

Rocks of the muscovite granite suite occur as a body located south of Mound Lake and as dikes intruding the metasedimentary and gneissic rocks to the north and south (*see* Figure 2). Irregular zones in the granite body and the dikes are composed of pegmatitic quartz, potassium feldspar, and plagioclase and frequently contain graphic intergrowths of quartz and feldspar, black, coarse-grained to pegmatitic, tabular tourmaline usually graphically intergrown with quartz and plumose intergrowths of muscovite-quartz (*see* Figure 2). Trace to 1% fine-grained, disseminated, subhedral, reddish brown garnet, fine-grained light green mica or rosy quartz were identified in a few of the dikes. These textures are commonly observed in rocks that have been classified as fertile granites, or granites that have the potential to host rare-element mineralization (Breaks, Selway and Tindle 2003). Samples of the muscovite, garnet and tourmaline are currently being examined to more accurately classify these granites.

Recommendations for Mineral Exploration

PLATINUM GROUP ELEMENTS

Recent diamond drilling in the Seagull intrusion has resulted in identification of a wider distribution of PGE mineralization (Platinum Group Metals Limited 2005). These results would be consistent with the interpretation of Heggie and Hollings (2004), which proposed that PGE mineralization is the result of sulphur saturation of magma during both the initial stages of emplacement and during subsequent injections of primitive magma. If the other ultramafic intrusions also formed as a result of multiple pulses of magma, then any portion of an intrusion has the potential to host PGE mineralization if the magma was PGE enriched at the time of emplacement.

The results of the inversion modelling of the gravity data for the Seagull and Hele intrusions outlined anomalies located at depth that would warrant further investigation. At the Seagull intrusion, the anomaly is located to the west of the peridotite outcropping, below the area between Seagull and Moraine lakes (*see* Figure 2; *see* Preliminary Map P.3562). This deep anomaly should be investigated as a feeder zone has yet to be identified and mineralization is being intersected in diamond drill holes located in the eastern portion of the intrusion. The anomaly associated with the Hele intrusion is located along the western edge of the surface expression of the intrusion and extends to the southwest toward Stewart Lake (*see* Figure 2). The Hele anomaly extends under the peridotite outcropping in northern Stirling Township and may also represent a feeder zone or an extension of the current intrusion to depth.

Recognition that the Hele intrusion may be formed by more than one pulse of magma means that there may be a potential for mineralization at a number of levels in the intrusion. Multiple zones of mineralization in the Seagull intrusion were only recognized as a result of detailed sampling, and much of the core of the Hele intrusion has not been sampled. Detailed sampling of the Hele intrusion drill core is warranted.

LEAD AND ZINC

There are a number of lead-zinc occurrences concentrated in the southern portion of the map within the area underlain by rocks of the Quetico Subprovince. The mineralization is hosted by unconformity-related vein systems hosted by fault breccias. There may be additional occurrences of this style of mineralization associated with the major fault systems in the area (*see* Figure 17). The fact that the unconformity-related lead-zinc-barite veins are reported to contain anomalous uranium values (e.g., Scott 1987), suggests that there may be a connection between this mineralization and unconformity-type uranium mineralization. Exploration programs should be designed to investigate both styles of mineralization.

Barite is a commonly reported accessory mineral in these veins and subhedral barite and quartz in an open-space fracture filling was observed in rocks of the Sibley Group located at the lamprey trap on the Wolf River, next to Highway 11/17. This was the only occurrence of barite in this form, and may be an indication of additional veins along the underlying unconformity.

URANIUM

The Tessier–Williamson, Hele Township, uranium occurrence is located in Hele Township along the eastside of the Black Sturgeon River and is hosted by biotite-quartz-feldspar gneiss intruded by granitic pegmatites. The presence of the granitic pegmatites suggests similarities with the Black Sturgeon Lake occurrence, which also has an associated pegmatite (Hart and Magyarosi 2004a). An age of 1090 Ma for mineralization reported by Ruzicka and LeCheminant (1984) suggests that existence of fluid circulation at approximately the same time, or shortly after, as the intrusion of the diabase sills. Hart and Magyarosi (2004a) suggested that the Black Sturgeon occurrence, located to the north of the current map area, has many of the features of vein uranium mineralization as described by Ruzicka (1996). This interpretation suggests that areas underlain by a faulted series of felsic intrusive rocks and clastic metasedimentary rocks, that are variably hematized and chloritized and adjacent to carbonate or quartz-carbonate veins, are the most favourable targets for uranium exploration. Areas with these characteristics include areas underlain by Archean metasedimentary and felsic intrusive rocks along the east side of the Black Sturgeon River that are cut by major regional faults and as blind mineralization targets beneath the Sibley Group to the west of the river (*see* Figure 17).

RARE METAL PEGMATITES

The pegmatitic, muscovite leucogranite body and dikes located east of the Black Sturgeon River contain intergrowths of tourmaline and quartz, and muscovite and quartz commonly observed in rocks that have been classified as fertile granites, or granites that have the potential to host rare-element mineralization (Breaks, Selway and Tindle 2003). Additional work is required to characterize these bodies. The muscovite leucogranite occurs along the regional trend extending from Georgia–Barbara lakes area in the northeast to the DeCourcey Lake and Onion Lake areas in the southwest (Breaks, Selway and Tindle 2003), and this area may represent a similar concentration of fertile granites. The fact that these bodies have been examined in only a cursory manner during this mapping program means that additional prospecting is recommended in the area between Mound Lake and the natural gas pipeline (*see* Figure 2).

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Metric Conversion Table

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Muluplied by*	*Gives*
			LENGTH		
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
			AREA		
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
			VOLUME		
1 cm^3	0.061 023	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.307 951	cubic yards	1 cubic yard	0.764 554 86	m^3
			CAPACITY		
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
			MASS		
1 g	0.035 273 962	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 747	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 622 6	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311 3	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 90**	t
			CONCENTRATION		
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	31.103 477	grams per ton (short)
1 gram per ton (short)	0.032 151	ounces (troy) per ton (short)
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.